THE HODGEN
WIRE CRADLE EXTENSION
SUSPENSION SPLINT

DOCTOR JOHN THOMPSON HODGEN

THE HODGEN WIRE CRADLE EXTENSION SUSPENSION SPLINT

THE EXEMPLIFICATION OF THIS SPLINT WITH OTHER HELPFUL APPLIANCES IN THE TREATMENT OF FRACTURES AND WOUNDS OF THE EXTREMITIES AND ITS APPLICATION IN BOTH CIVIL AND WAR PRACTICE

BY

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With an introduction by

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WITH 124 ILLUSTRATIONS

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THIS LITTLE BOOK IS DEDICATED TO THOSE MEMBERS OF THE MOST ALTRUISTIC OF ALL PROFESSIONS WHO ARE SERVING HUMANITY IN THE GREAT WAR.

PREFACE

No apology will be made for the appearance of this little book. To some critics it may appear as a rather sophomoric effort, lacking in form and literary merit. All such possible criticism will be borne with patience and good will. But criticism of the appliance herein described, most useful and serviceable as it has proved, will be regarded as a challenge that will not fail to produce energetic combat.

Any book, big or little, has excuse for its being if it contains but one valuable new idea; and a little book may well have worth if a valuable old idea is refurbished and made applicable.

There is a multiplicity of war books just now, dealing with the various phases of war problems. Medical science may well feel proud of its service. Without modern medical science, the war would even now be finished by sepsis and epidemics. Still, medical science is continually progressive in these latter days; and we are never content with present achievements.

The author has been much interested in watching the methods of fracture treatment, especially those used for the lower extremities. The subject has been much neglected by our surgeons in civil practice. The author is convinced that there is now an imperative call for a better understanding of the basic scientific principles of fracture treatment; the more necessary on account of the service needed in the war. And what are these principles? Nothing more than a sane and common-sense application of the laws of physics and mechanics, adapted through appliances to the repair of wounds and fractures, and contributing to the comfort and general welfare of our patients.

Anyone reviewing the old methods of fracture treatment will not fail to notice that there is much to be desired. Some of the appliances pictured in the old texts might fittingly illustrate the instruments of torture used in the Spanish Inquisition. Even some of the more recent devices for fracture treatment have not improved upon these materially; but a goodly number are admirable; and they appear to be so, so far as they have applied the fundamental principles of the Hodgen splint. Many methods have considered that bony union was synonymous with recovery, which is not so. Good functional recovery should be the attainment.

Our Civil War produced a great advance in the treatment of fracture of the femur. Gurdon Buck gave us his extension. Nathan Ryno Smith gave us his suspension splint. John Thompson Hodgen, by his ingenuity, combined both valuable features in one, and produced his suspension extension splint.

It is a patriotic impulse that impels the author, a neophyte, to make this effort to explain, as lucidly as he may, this appliance and its proper application. He realizes that it could be taught much better by master to pupil; having the knowledge and art passed on from one to another. It is his hope that this may be done, until the great usefulness and efficiency of this splint becomes known and thoroughly popularized. This, then, is the object of this little book. It is written for men thoroughly acquainted with anatomy and the subject of fractures in general. No effort is made to compile a "big book." It is the desire to be as concise as possible, and with singleness of purpose teach the virtues of the Hodgen extension suspension splint.

Frank G. Nifong.

Columbia, Mo.

INTRODUCTION

By Harvey G. Mudd, M. D.

John Thompson Hodgen was born at Hodgenville, La Rue County, Kentucky, January, 1826. His father was Jacob Hodgen, his mother Frances Park Brown. He attended the common schools of Pittsfield, Pike County, Illinois, and afterward Bethany College, West Virginia.

He graduated March, 1848, from the Medical Department of the University of the State of Missouri—known at the time as McDowell's College. He served in the St. Louis City Hospital as assistant resident physician and, afterward, as resident physician from April, 1848, to June, 1849. He was Demonstrator of Anatomy in McDowell College from 1849 to 1853. He was appointed Professor of Anatomy by Joseph Nash McDowell and filled this chair from 1854 to 1858. Subsequently he filled the chairs both of anatomy and physiology from 1858 to 1864.

In 1864 he was called to the St. Louis Medical College, filling respectively the chairs of physiology and anatomy. In 1875 he became Professor of Surgical Anatomy, Special Fractures and Dislocations; and was also elected Dean of the Faculty. This position he held up to the time of his demise.

From 1864, until his death, he taught clinical surgery at the City Hospital. During the Civil War he served as Surgeon-General of the Western Sanitary Commission, 1861; Surgeon U. S. Volunteers, 1861-1864; and as Surgeon-General, State of Missouri, 1862-1864.

He was consulting surgeon to the City Hospital, 1862-

1882; President of the St. Louis Medical Society in 1872, Chairman of the Surgical Section of the American Medical Association in 1873, President of the Missouri State Medical Association in 1876, and President of the American Medical Association in 1880.

He died April 28, 1882, after an illness of two days, of acute peritonitis, caused by pinhole perforation of an ulcer of the gall bladder.

Dr. Hodgen loved his profession and loved humanity. He was a close and constant student. His was an active brain—never for one moment idle. He had, to a noteworthy degree, mechanical genius which found play in the application of mechanical means to the uses of surgery. I may mention a wire suspension splint for injuries of the arm—a forceps dilator for removal of foreign bodies from the air passage without tracheotomy—the application of suspension cord and pulleys permitting flexion, extension and rotation in fractures of the leg—a hair-pin dilator for separating the lips of the opening in the trachea and the Hodgen suspension splint for use in fracture of the thigh.

The use of a bent hair pin with the wire end stuck in a cork is an example of the adaptation of simple means to an end which still remains the best dilator of the tracheal opening and guide in introducing the tracheal tube.

His suspension splint for fractures of the thigh was a modification of the Nathan R. Smith anterior splint and was especially designed during our Civil War for the treatment of compound (gunshot) fractures of the thigh.

Dr. Hodgen's time was so fully taken up during the later years of his life that his writings were not extensive. We may mention among other notable contribu-

tions articles on "Wiring the Clavicle and Acromion for Dislocation of the Scapular End of the Clavicle"—"Nerve Section for Neuralgia"—"Use of Atropia in Collapse of Cholera."

As a teacher Dr. Hodgen stood pre-eminent and his memory will linger and be an influence in the lives of those who had the good fortune to know him in this way, so long as life endures.

He had a big, warm, generous nature well recognized by those who came to know him as he was, but this quality sometimes went unrecognized because of a somewhat reserved, even austere manner. He was full of a kindly humor. He died as he had lived "in the harness," a friend to humanity. He had always wished to go before his usefulness was in any degree diminished. Honest, frank, direct, a great soul—"We shall not see his like again."

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CHAPTER I

CONSIDERING SOME PERTINENT ANATOMIC FACTS

To be an efficient mechanical engineer one must be thoroughly acquainted with the materials with which he constructs his machine and have a definite knowledge of the forces transmitted through its various parts if he hopes to construct a functioning engine. It presupposes a knowledge of physics and mechanics, and demands a practical application of their laws to enable him to build or repair a machine that has broken down. If he has this fundamental knowledge, it goes without saying that the mechanic gives the best service who has experience in such work and uses also a goodly amount of commonsense. The skilled engineer easily transmits definite forces through the various parts of his machine for specific purposes. Machines, such as printing presses and adding machines, are constructed by him that are as marvelous as they are intricate.

Not nearly so intricate, from a mechanical point of view, is the mechanism of the human body. The forces applied through bone and muscle are elementary and simple compared to many of our complex modern machines. True, the surgeon has many things to consider other than the mechanics of the body, for he is dealing with the living cell, not with things inanimate. That fact

does not, however, excuse him for violating the most elementary of mechanical principles; it should make him strive to be more skillful in adapting his mechanical appliances to suit the demands of a case. As we have just intimated, the mechanical problems in fracture treatment are not so difficult; they really have to do with elementary laws. Many of our surgical appliances designed for treating fractures reflect no credit on the profession of surgery. Some of them disregard the welfare and general comfort of the patient, and would be more fittingly described as instruments of torture. Others violate the most simple mechanical laws, and signally fail to render the assistance to nature for which they were presumably designed.

The very foundation of medicine and surgery has always been recognized as a thorough knowledge of physiology and anatomy.

In the treatment of fractures the demand is for a knowledge of these fundamentals from a mechanical point of view. From such a point of view, let us observe the articulated bones in relation to the general contour of the body (Fig. 1). Most of them are admirably adapted for the functions to be performed; for locomotion; for encasing vital organs; and for supporting superincumbent weight. They are joined together by symphysis, suture, and various types of true joints, according to the functions to be performed. This framework strongly bound together by ligaments is then vitalized into a wonderful machine through the forces exerted through muscles extending from point to point. These muscles in groups transmit the various forces to the bones, and determine the complex movements of the body. Forces and counterforces exerted through the

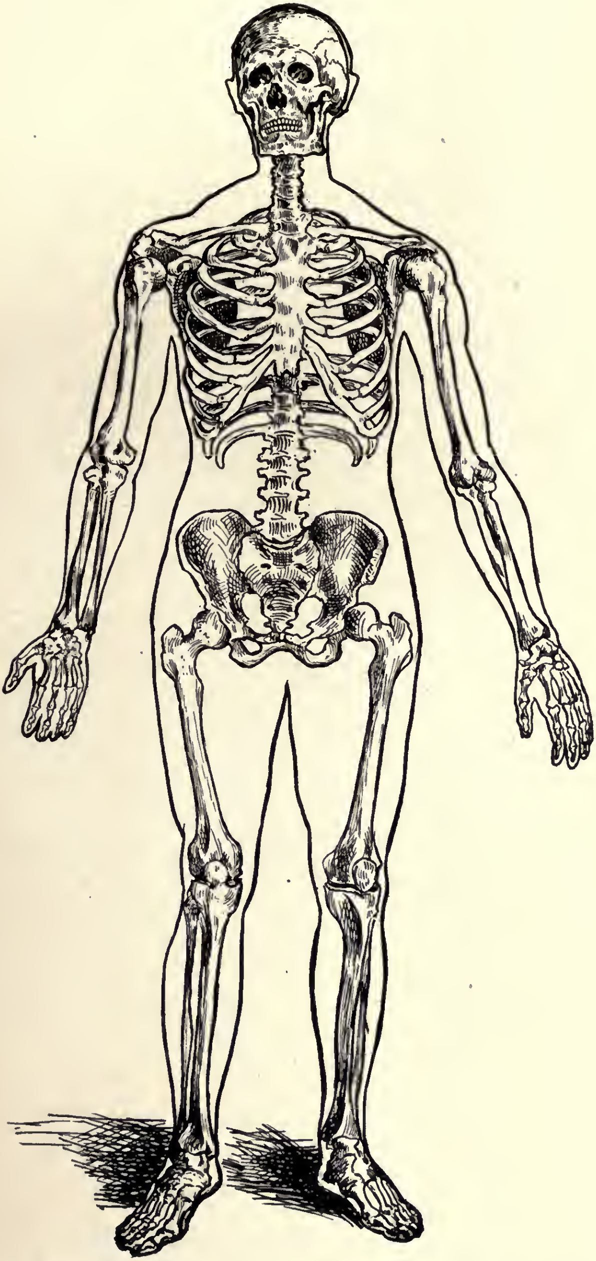

Fig. 1.—The skeleton in relation to the contour of the body.

several groups of muscles determine the movements of extension, flexion, rotation, abduction and adduction according to the enervation. Now, when a fracture is received, when there is a severance of bony continuity, is it that alone that must be considered, or must we give thought to the multiple forces exerted through the muscles?

Fig. 2.—Section of the upper extremity of a normal femur at eight years of age; angle formed by the neck with the shaft 140 degrees. In the normal subject the neck of the femur projects slightly forward (12 degrees) and upward to form an angle with the shaft of about 125 degrees. In childhood this angle is usually somewhat greater, and in later years it may be somewhat less than 125 degrees; in fact, a variation between 110 and 140 degrees may be within the normal limit. Both anterior torsion and upward inclination are much greater at birth than in adult life. The length of the neck varies from 5.9 to 8.17 per cent of the length of the shaft. (Whitman—*Orthopedic Surgery.*)

More particularly, then, let us note the femur and some of the things that should be considered from a *mechanico-anatomic* point of view when we have to treat its fractures. The femur, the largest and strongest long bone in the body, seems admirably fashioned to serve the uses for which it was intended. If its only functions were the support of the body and straight forward locomotion it might have been hinged to the pelvis and made much

straighter. The superincumbent weight transmitted through the long axis of the bone would not demand a structure so strong and heavy, if that were all that is needed. But the need is for a structure to bear the superincumbent weight in a multitude of varying positions, and to have forces applied to it in numerous and varying directions, so that its strength must greatly exceed that needed for ordinary locomotion. It must be strong enough for all ordinary functioning, and have much additional strength in reserve as a factor of safety. It must be stronger because of the need that it be angled out at the trochanter from the axial line passing through the hip and knee making a triangle, for in no other efficient way could muscular action make the rotation that is so necessary and help in the other motions. Therefore, at this trochanteric angle, which is approximately 127 degrees (Fig. 2), we have a massing of additional bony tissue, making more strength and an advantageous point for the application of force. Also, we note the strong forward curvature of the shaft of the femur, and, posteriorily, there is an added bony ridge, "linea aspera," which greatly strengthens the bone, as an angle iron principle in engineering would add strength, without greatly increasing weight. To this bony ridge there is an advantageous attachment of muscles and fascia through which the forces are applied to the strong concave side of the arched bone.

Not the least important factor to be considered in the common-sense application of mechanical laws to fractured femurs is the construction of the hip joint (Fig. 3). Too often the surgeon forgets the functioning of such a ball-and-socket joint, which permits motion in an indefinite and varying number of axes; and he treats it as if

only a straight back-and-forth motion, such as is permitted in hinge joints, were possible. Now the hinge joint has a single back-and-forth movement in one axis,

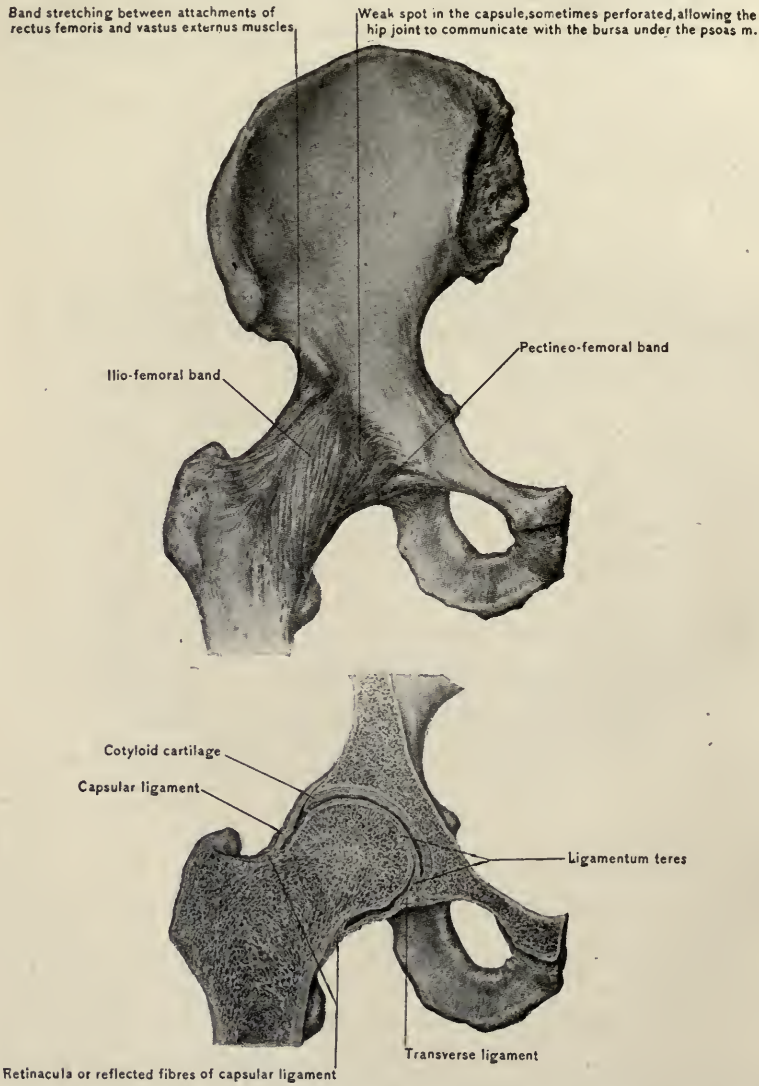

Fig. 3.—Anterior view and longitudinal section of the hip joint. (Deaver—*Surgical Anatomy.*)

and any force applied deviating from that axis would be transmitted to the point of fracture above or below the joint. Hence the necessity for immobilizing the joint. Now a ball-and-socket joint, such as the hip and shoulder, which acts so freely through every radius from a central point, does not need immobilizing, except as to the extent of the limitations of its movements made by its capsule and ligaments. Outward and inward rotation, adduction, abduction, flexion, and extension, and all the varying composites of these motions, are secured through the muscular action and the wonderfully free movement secured at the end of the bone by this ball-and-socket joint. So freely movable is this joint that no force may be transmitted through the joints to the point of fracture until the ball-and-socket movement in any direction reaches its limitations. Flexion is only limited by contact of the thigh on the trunk; extension is limited by the strong iliofemoral band; abduction is limited by the pubofemoral ligaments; adduction is also limited by the iliofemoral ligament. Outward and inward rotation are likewise limited by the capsule and overlying ligaments. So wide are these margins of limitation in the motion of the joint that in practice we should never find need for immobilizing it. There is never any demand for hyperextension. Abduction to as much as 45 degrees is often needed and permitted by the joint. The maximum of flexion of the thigh is always possible; therefore, a proper understanding of the structure of this joint and its great range of free motion in every direction will permit one to comprehend readily the principles of treatment exemplified in the use of suspension extension splints, which permit the utmost mobility at the hip or shoulder joint, as will be shown in a subsequent chapter.

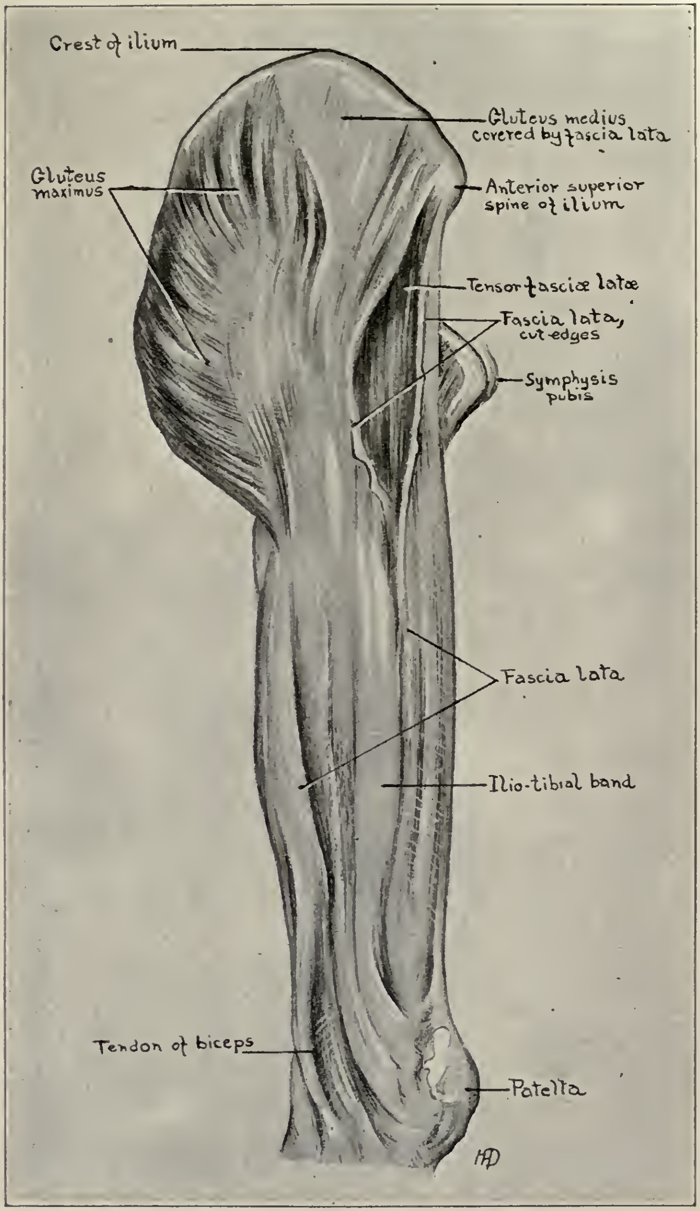

Fig. 4.—Lateral surface of right thigh invested by fascia lata.

Another structure of scarcely less importance than the ball-and-socket hip joint is the great fascia lata enveloping the thigh. For preserving the contour of the muscles, and assisting in directing the application of forces through these muscles, this structure is of prime importance, and is to be duly considered from a mechanical point of view in treating fractures of the thigh.

The fascia lata is a great fibrous sheath (Fig. 4) enveloping the thigh with attachments above from Poupart's ligament, the crest of the ilium, the great sacrosciatic ligament, the sacrum and coccyx, the body of the pubis and rami of the pubis and ischium. This tubular sheath from these attachments above envelopes the entire musculature of the thigh, and is attached at the knee to the condyles of the femur, to the inner and outer tibial tuberosities, the head of the fibula, thus covering the knee joint and further strengthening its ligamentous security. Now this tubular sheath is further strengthened by giving off two septa, which pass between the muscles and attach to the outer and inner lip of the linea aspera (Fig. 5), thus dividing the muscles into two separate compartments, the anterior extensors and the posterior flexors and adductors. This posterior compartment is further divided by an intermuscular septum making a separate section for the adductors, and another for the great flexors. Externally, this facia is much the thickest, and from the crest of the ilium, over the trochanter to the outer tuberosity of the tibia and head of the fibula, is known as the "iliotibial band." This great thickened band of fascia, into which is inserted the tensor fascia femoris and two-thirds of the gluteus maximus muscle, is a very important factor in steadying the pelvis and maintaining the knee joint extension, when

the body is erect. This tense sheath is the structure which holds the softer musculature in its proper place, and has much to do in directing and modifying the direction of the force transmitted through these muscles. This double attachment to the bone itself through the intermuscular septa still further emphasizes its impor-

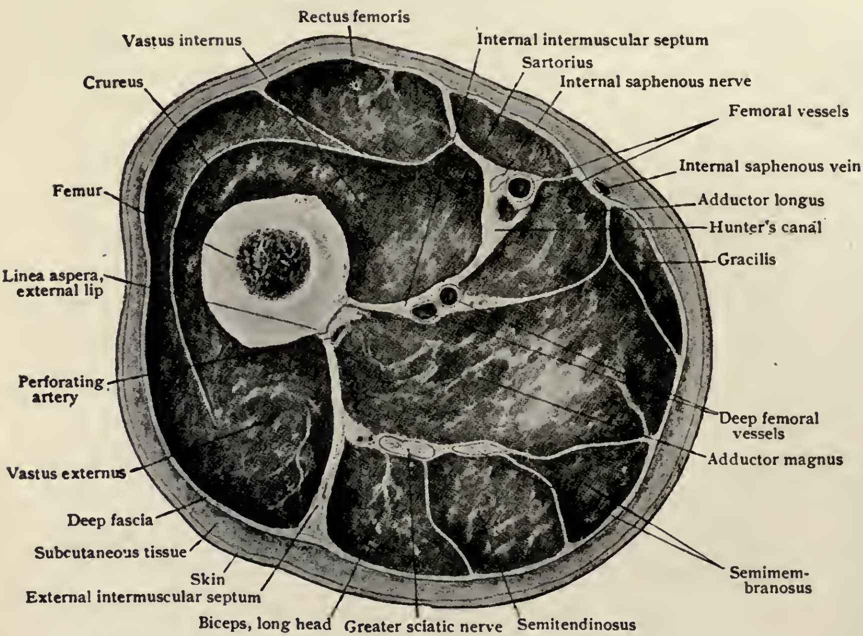

Fig. 5.—Section across right thigh through Hunter's canal, seen from below. Showing intermuscular septa and attachment to linea aspera. (Piersol—*Human Anatomy.*)

tance, as it makes still more secure both form and function, keeping the long muscles in their proper compartments, and directing their forces most advantageously. These functional forces are transmitted through the bone which is attached to the intermuscular septa and in the center of the sheath. Do not forget that these compart-

ments are completely filled with muscles and soft parts. When a fracture occurs with shortening there is much relaxation of this fascia, which is always normally tense; displacement of the ends of the bone occurs according to the location of the fracture and the muscle pull. Now, when this fascia is stretched back to normal, the tendency is for the muscles to fill their proper compartments and the structure of the sheath with its intermuscular septa attached to the linea aspera of the bone makes the bone return to its normal place. This is a factor of great importance from a mechanical point of view, and demonstrates the necessity for the use of extension as a most important requisite in the treatment of fractures of long bones with great muscle attachments. Imagine a canvas sheath with attachment to rings at the end. Imagine a partition of like material attached to a stick representing the femur in the center. We break the stick and relax the tension on the sheath one or two inches, and the ends of the stick displace and overlap and angulate, if the sheath be bent. Now make extension on the rings of the sheath and the stick resumes its normal position, being brought back by its attachment to the canvas. In the case of the femur it returns to normal position by reason of its attachment to the intermuscular septa and the pressure of the muscles being extended to normal position in their several compartments. With a proper understanding of this fascia lata, a good and sufficient mechanical reason for the use of extension in fractures is at hand.

The thing to be most considered in diagnosing and treating fractures of the long bones is the site of the fracture and the several forces exerted through the muscles making the shortening and displacement. This pre-

supposes a knowledge of the attachments and functions of the muscles, both singly and in groups. Shortening there must be in all fractures of the femur, except the slightly impacted neck or a transverse shaft fracture without displacement. This shortening is unavoidable on account of the tremendous pull from the great hamstring and extensor muscles. The displacement of the upper or lower fragments depends on the pull exerted by the abductor group of muscles, the psoas and iliacus pulling up and forward; the glutei rotating the trochanter; and the muscles of the calf of the leg pulling

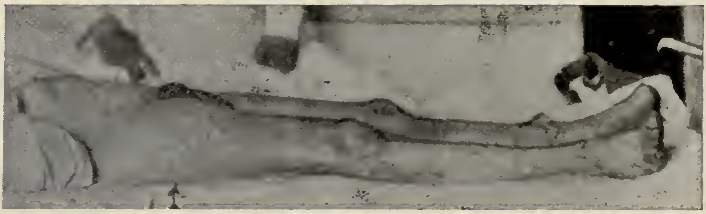

Fig. 6.—Fracture of right femur through great trochanter. Note thickening of the thigh in its upper part and the eversion of the lower extremity. Compare the levels of the two knees which are directly in front of the camera. Right thigh slightly shorter. Picture taken a few minutes following the injury. (Preston—*Fractures and Dislocations.*)

downward and backward the lower fragment, when the fracture is in the lower third of the shaft. In a fracture of the neck of the femur, the long flexors and extensors pull the shaft upward, and the shortening may be one or more inches. The trochanteric muscles tend to rotate the shaft outward, helped by the natural weight of the limb (Fig. 6). A fracture of the shaft at the middle and upper third will displace the lower fragment backward, and the upper one will be pulled forward by the psoas and iliacus muscles and rotated outward by the trochanteric bunch of muscles (Fig. 7). Also, at the junction of the lower and middle third, we will note the pulling down

and back of the lower fragment by the gastrocnemii, and the forward displacement from the psoas and iliacus and inward displacement by the adductors.

Such are some of the forms of fracture which may be

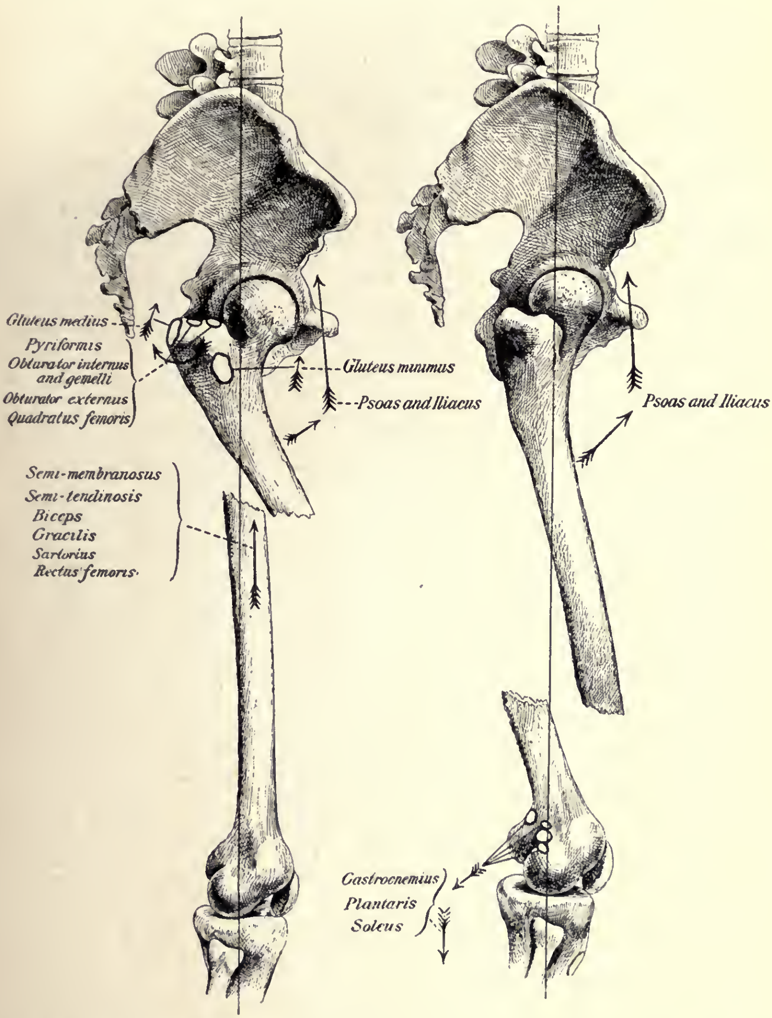

Fig. 7.—Fractures of the shaft of the femur. (Deaver—*Surgical Anatomy.*)

modified and variously changed by obliquity, comminution, and such circumstances, as may be observed in Fig. 8.

The obliquity of fractures of the femur shaft is usually from the posterior above downward and forward, leav-

Fig. 8.—Lines of fracture of femur. (Piersol—*Human Anatomy*.)

ing the lower fragment to be pulled upward and backward, and the anterior upper fragment to be pulled forward and outward, if the fracture is high, or forward and inward as it may be below the insertion of the great adductor muscles. We can imagine the obliquity of the

fracture modifying these positions, for the fracture may be oblique from the front downward and backward, and this obliquity might prevent the displacement forward and outward of the upper fragment, or the backward displacement of the lower fragment. So, we see, much of our success in management is dependent on a knowledge of these varying forces and conditions and sufficient mechanical sense to counteract them.

There is still one more point to be mentioned which is an anatomic consideration, and applies particularly to the methods of treatment hereinafter described. Whatever methods or appliances are used, the endeavor should be to restore the limb anatomically and in good form, for it is a fact that good anatomic form is almost synonymous with good function.

Good function, of course, is the prime requisite, and it is possible to have that without good form. We quote the report of the Fracture Committee of the British Medical Association (*British Medical Journal,* 1912, p. 1525): "An analysis of all the results nonoperative and operative clearly shows the interdependence of anatomic and functional results. The total number of cases in which a good anatomic result was obtained is 1,736, and in no less than 1,576 of these the functional result was also good. In other words, if the anatomic result is good, the functional result is good in 90.7 per cent. If the anatomic result is moderate or bad, the functional result is good in 29.7 per cent (i. e., 380 out of 1,279). If the anatomic result is bad, the functional result is bad in 53.3 per cent (176 out of 330)."

These conclusions of the Fracture Committee are broad, but in a general way they indicate that the safest proposition is one in which we make every effort to re-

store form and proper anatomy, and we can then reasonably conclude that we may get good function in 90 per cent of the cases. However, if proper form is not obtained, we may reasonably hope to have a fair percentage of cases with good function. The ability to judge of contour and anatomic relationship by inspection, palpation, and by comparison with the sound limb, is of much value in restoring the normal anatomy; and the appliances which will permit this are consequently of relatively more value than those which do not do so. This fact will be demonstrated when considering the various appliances for treating fractured femurs.

CHAPTER II

FRACTURES OF THE FEMUR

Classification, Etiology and Diagnosis

It would serve no useful purpose to go minutely into the causes of fracture and review the various classifications. Such information is abundantly given in various texts, both modern and ancient. Even the question as to whether the fracture was caused by direct external violence or indirect external violence, is not of major consequence in the consideration of treatment, but may be a factor of importance in diagnosis.

When the force is applied directly over the point of fracture, we have an example of fracture produced by direct external violence. A torsion of the limb or avulsion combined with muscular action may produce fracture of the shaft of long bones. Fracture by muscular action alone is possible in long bones, but usually there must be some resisting external force exerted in conjunction with the muscular action. Indeed, a factor in fracture by direct violence is the tense muscular resistance almost always exhibited. The muscular action must always be considered in every fracture of long bones, primarily as a force entering into the causes of the fracture, and secondarily as the force causing displacement and deformity. Say an immovable resistance is encountered by the lower end of the femur and the great extension muscles endeavor to overcome it, such muscular action may fracture the bone; or a direct force may be applied to the

middle of the shaft of the femur, and added to that is usually the strong resisting muscular action which is exerted on the shaft of the bone. Example of fracture by direct external violence without muscular action would be that produced by gunshot or similar forces.

The so-called "spontaneous" fractures are those which seem to be caused by much less than the usual necessary force, either external or muscular. Back of all such cases we will find some pathologic change in the bone. It may be that due to senility, a general atrophy and rarefaction of the bone, accompanied by a change in the trochanteric angle of support in the case of the femur. Old persons frequently break the neck of the femur by simply hanging a toe on an obstruction. A very slight resistance and suddenly increased muscular exertion will cause the fracture.

In younger persons, however, most spontaneous fractures are really caused by pathologic changes, an osteoporosis due to the effects of cachectic disease. Diabetes, syphilis, osteomalacia, and rachitis are not infrequently the remote causes. Carcinoma and sarcoma metastases, or the primary location in bone, may lead to fracture. The malignancy located elsewhere in the body may produce a cachexia, which may result in bony atrophy and spontaneous fracture.

Diagnosis

There have been from time immemorial certain classical signs and symptoms of fractures. Pity for the dear patient whose surgeon feels it his duty to demonstrate them all; whose surgeon, after getting his *history,* noting his *pain* and *loss of function,* finds it necessary to demonstrate well the *deformity* and *abnormal mobility* of the

limb by manipulation and finally by persistent and often violent effort elicit the grinding, crunching *crepitus* sound so pleasing and conclusive to his ear. Certainly to be humane is not inconsistent with a surgeon's dignity, and gentleness makes him none the less efficient.

To make the diagnosis of fracture of the femur, for instance, the surgeon should have poise and a certain gentleness and dignity. The confidence of the patient and the respect of those attending must be secured at once. With no hurry, but with a certain directness, the surgeon gets the history of the accident; he assures his patient of his sincere desire to produce the minimum amount of pain in his examination. In getting the history of the accident sympathetically, the surgeon secures the psychologic status necessary, and makes it possible to proceed further with his examination without undue pain and excitement. Gently the clothing should be cut away, without moving the limb. The eye detects the loss of contour, the lack of symmetry with the opposite limb, the angulation or the deformity. From the history alone he may have made a correct diagnosis. The inspection alone may have determined by the angulation the exact site of the fracture. A gentle passage of the hand or finger over the limb will often detect the most sensitive point over the site of fracture, should there be no deformity. If, with such gentle methods, he may make a diagnosis, his humane instincts should prevent the rough, injurious, and painful manipulations demonstrating excessive mobility and crepitus, though he has not the better judgment. With a limb already lacerated and pricked with sharp broken bone, with muscles painful and in spasms, it is, as a rule, not only unnecessary, but absolutely brutal, to damage the limb further by rough

manipulation. Such work can accomplish nothing; it may greatly increase the injury, completing partial fractures, separating impacted ones, seriously damaging soft parts, vessels, nerve, and muscle, increasing inflammation, swelling, and pain, possibly even determining gangrene and death. It is the surgeon's duty, after making the diagnosis, to give his patient first aid. To transport him to his place for recovery with the apparatus applied which will secure him from further injury and give him the most ease in transit. Our latest diagnostic aid, the x-ray (see Chapter VIII, Figs. 94, 95, 96, and 97) adds much to our efficiency, as well as to our humanity in diagnosis. This should always be used, whenever possible, not to demonstrate deformities, after they have occurred, in courts of law, but as a routine method in diagnosis and aid in using the proper appliances to prevent deformity.

Diagnosis of Fractures of the Neck of Femur

According to von Brun's statistics (von Bergman: *System of Surgery*), the frequency of fractures of the femur is about 6 per cent, and one-fourth of these are in the neck, occurring mostly in old age. After the seventieth year, the fractures of the neck of the femur constitute a third of all fractures. Fractures of the neck, both intracapsular and extracapsular are peculiarly those of old age, due to those senile changes in the bone structure, and the change in the angle of the neck at the trochanter more nearly approaching a right angle (coxa vara) (Fig. 9), and therefore much less able to support the superincumbent weight. The neck of the femur is apt to break in two places: at the junction of the head and neck, or at the junction of the neck and trochanter;

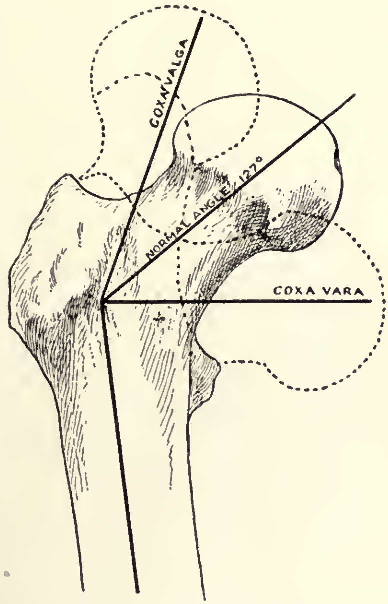

Fig. 9.—Normal angle of the head and neck to the shaft of the femur with the alteration in position in coxa valga and coxa vara shown by dotted lines. (Davis—*Applied Anatomy.*)

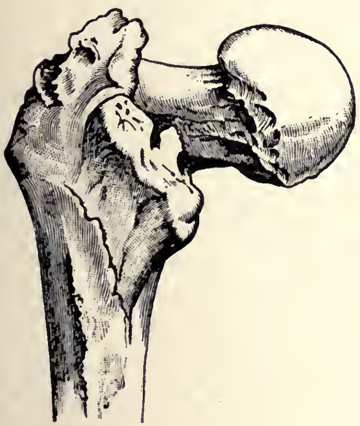

Fig. 11.

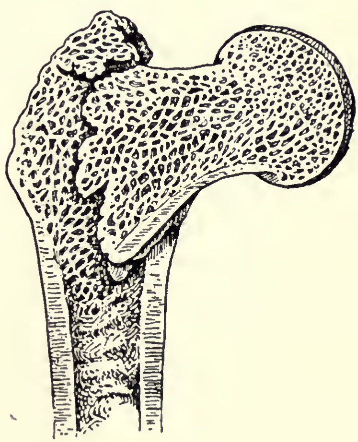

Fig. 10.

Figs. 10 and 11.—Impacted extracapsular fracture of the neck. (von Bergman—*System of Surgery.* After Lossen.)

and, as it may be one or the other, they are intracapsular or extracapsular.

A mixed fracture is one in which the capsule covers the fracture line in front but not behind, as posteriorly

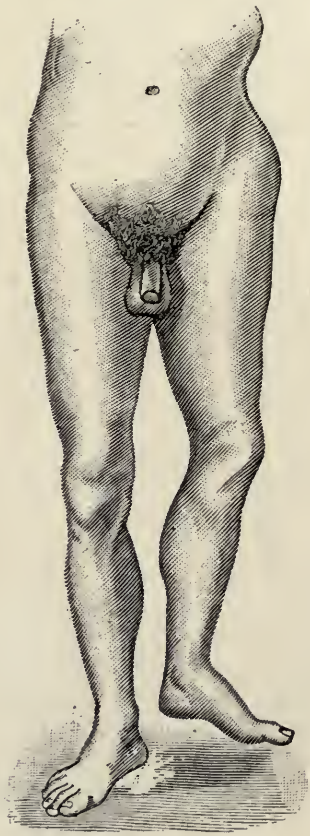

Fig. 12.—Fracture of the neck of the femur. (von Bergman—*System of Surgery.*)

the capsule extends only to the middle of the neck. The history of the injury will be of much assistance to the surgeon if he finds his old person has received a blow or has fallen on his trochanter. He may have an impacted

fracture of the neck (Figs. 10 and 11). A fall on the foot or knee, transmitting the force through the long axis of the femur, causes fracture of the neck near the head.

In fracture from muscular action, as when an old person stumbles and quickly throws his body back for

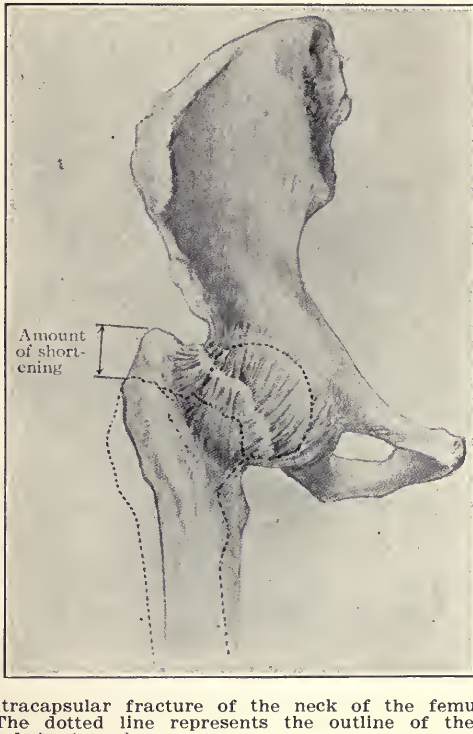

Fig. 13.—Intracapsular fracture of the neck of the femur showing the shortening. The dotted line represents the outline of the normal bone. (Davis—*Applied Anatomy.*)

equilibrium, hyperextension tightens the iliofemoral ligament and by its great strength tears the neck from its base. When the surgeon sees this patient he will notice (Fig. 12), the greater or less shortening, according to whether the fracture is impacted or complete. He will notice the change in contour of the hip, the obliterated

inguinal fold, possible ecchymosis and swelling, the outward rotation which is greater if there is no impaction. This eversion is due mostly to the greater weight of the limb being outside of the axial line extending through the anterior superior spine of the ilium and through the great toe.

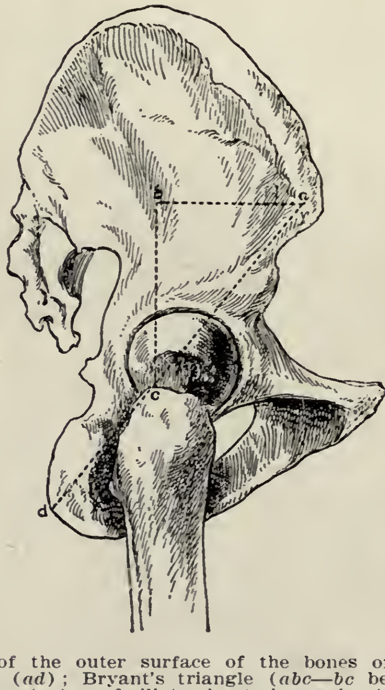

Fig. 14.—View of the outer surface of the bones of the hip, showing Roser-Nélaton line (*ad*); Bryant's triangle (*abc*—*bc* being its base); the iliotrochanteric line (*ac*) and iliotrochanteric angle (*bac*). (Davis—*Applied Anatomy.*)

Outward rotation (Fig. 12) and shortening (Figs. 13 and 14), are the most important symptoms of fracture of the neck of the femur. Shortening with impaction is rarely more than one inch, the intracapsular fractures rarely more than one and one-half inches. If the capsule gives way, or it is an extracapsular fracture, the shortening may be as much as three or four inches. To

determine this shortening, which is so important a diagnostic point, certain plans of measurement have been devised. The Nélaton line and Bryant's triangle (Fig. 15) are shown in the accompanying figure.

The Nélaton line extends from the anterior superior spine of the ilium to the tuberosity of the ischium and crosses the top of the great trochanter. A fracture produces nonalignment. Bryant's triangle is made by dropping a line vertically from the anterior superior spine of the ilium to the couch, when the patient is supine. Draw a line through the trochanter at right angles to this vertical line. This line is shorter than that of the

Fig. 15.—Mapping out of Bryant's triangle and Nélaton's line. A line drawn from the anterior superior iliac spine to the tuberosity of the ischium is known as Nélaton's line and should about touch the top of the great trochanter. A vertical line dropped from the anterior superior iliac spine to the table on which the patient lies and a vertical line extended upward from the top of the great trochanter form two sides of Bryant's triangle while the third side is formed by Nélaton's line. Bryant's triangle—*XYZ*. In fractures of the femoral neck the distance *YZ* is usually shortened. *AS* the anterior superior iliac spine. *S* Symphysis pubis. *TI* Tuber ischii. (Preston—*Fractures and Dislocations.*)

opposite hip if there is a fracture. Nélaton's line completes the other side of the triangle. Morris' line in Fig. 17 shows measurements of the trochanter nearest the median line in fracture of the neck, and the lines in Fig. 16 demonstrate the shortening of the base of Bryant's triangle. Measuring the length of the limb from the bony prominences of the pelvis to the malleoli will also demonstrate definitely the shortening and upward pull of the thigh (Figs. 18 and 19).

In the previous chapter we have tried to show the great importance of the fascia lata in the fractures of

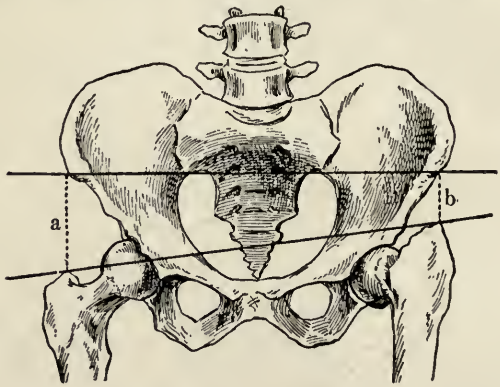

Fig. 16.—Showing elevation of tip of trochanter and shortening of base of Bryant's triangle in fracture of neck of femur; *a*, base on sound side; *b*, on fractured side. (Piersol—*Human Anatomy.*)

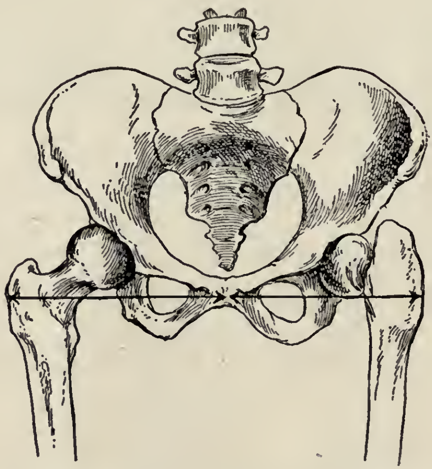

Fig. 17.—Morris' measurements to show the trochanter of the injured side nearer the median line in fracture of neck of femur. (Piersol—*Human Anatomy.*)

the thigh, from a mechanico-anatomic point of view. The laxity of the fascia lata, the portion known as the iliotibial band between the crest of the ilium and the tro-

Fig. 18.

Fig. 19.

Figs. 18 and 19.—Measuring the length of the lower extremity from the anterior superior iliac spine to the tip of the internal malleolus. The legs should be parallel and the pelvis should not be tipped. In other words a line drawn through the anterior superior iliac spines should be at right angles with the median plane of the body. (Preston—*Fractures and Dislocations.*)

chanter, is considered an important diagnostic evidence of fracture of the neck of the femur (Figs. 4, 20 and 21). Shortening of the bone after fracture relaxes this strong fibrous sheath; so even by inspection we notice the depression above the trochanter, and by palpation as shown

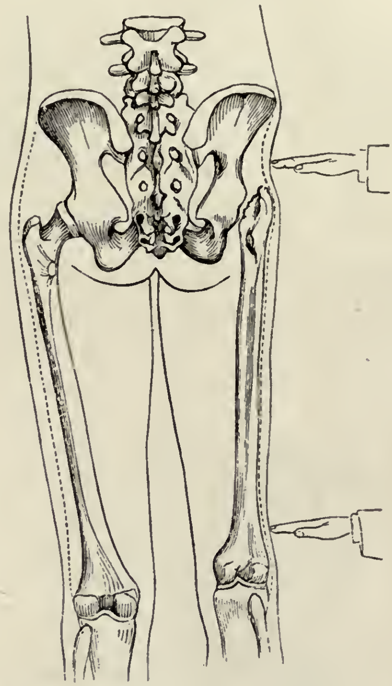

Fig. 20.—Method of recognizing the relaxation of the fascia lata after fracture of the neck of the femur. (Hamilton—*Fractures and Dislocations*. After Allis.)

in Fig. 20 we demonstrate the general laxity and lack of resistance of this sheath, compared to the opposite limb. Most of the difficulties of diagnosis encountered in fractures of the femur are those in the neck, and these methods, assisted by x-ray examinations, will make it always possible to make a correct diagnosis without manipulation and rough usage to obtain crepitus, which may produce more or less serious additional damage.

The diagnosis of fractures of the shaft of the femur are much less difficult. The frequency of fracture is greatest in the middle, upper and lower thirds, in order, occurring especially in laborers and children. Frequently they result also from severe direct violence in accidents and gunshot fractures in war. They are often accompanied by severe lacerations and serious injuries to the soft parts; and the treatment of the soft parts demands even more consideration than the bone.

Indirect forces, such as falling on the feet, with the force transmitted produces fracture most often in the upper and in the middle third. A bow fracture of the

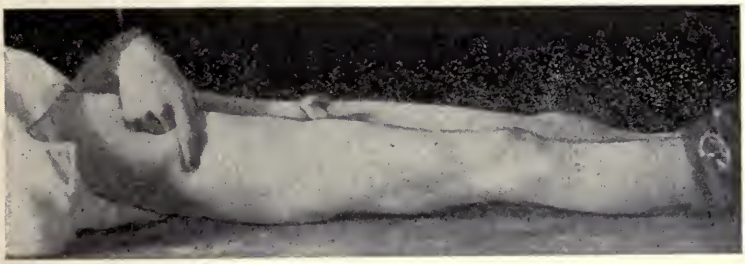

Fig. 21.—Picture taken to show how the fascia lata becomes lax between the iliac crest and the trochanter when the latter is raised through fracture or disease. (Preston—*Fractures and Dislocations.*)

femur is made by being bent in its forward convexity beyond the limit. Transverse, oblique, spiral (Fig. 22) and multiple fractures are all found according to the complex forces entering in as causes. Notwithstanding this diversity of the forms of fracture that may be found, the femur follows, as a rule, rather definite laws. In the upper third the fracture is almost always oblique from above, and from without downward and inward. In the middle third, from above and behind, obliquely downward and forward. In the lower third, more slightly oblique from above, and behind, downward and forward. In such a

fracture of the upper third of the femur, the upper fragment is abducted and slightly flexed by the iliopsoas and glutei muscles. The lower fragment is pulled inward by the abductors and upward by the great flexors and extensors pulling longitudinally, thereby producing shortening, the fragments overriding (Fig. 23). The pain, loss of function, deformity, angulation, and shortening

Fig. 22.—Spiral fracture of the femur. (von Bergman—*System of Surgery*. After von Bruns.)

are so apparent that diagnosis is easy without manipulation. Likewise, in fractures of the middle third, the upper fragment is usually displaced forward and outward if the fracture is near the junction of the upper and middle thirds; but if near the junction of the lower and middle thirds, the great adductors may draw the upper fragments forward and inward, and the lower will be dis-

placed outward and backward with upward shortening. In the fracture of the lower third, the adductors draw

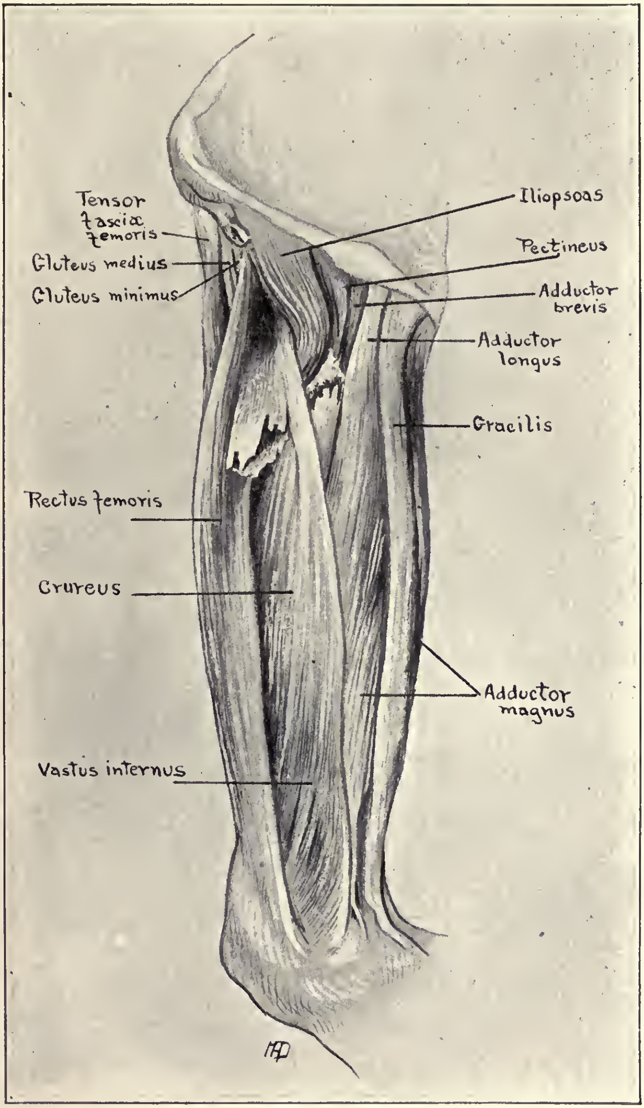

Fig. 23.—Fracture of the femur at the juncture of the upper and middle thirds. Upper fragment drawn forward and outward.

the upper fragment forward and inward; the lower fragment being drawn upward and backward. Sometimes a fracture in the lower third just above the condyles will be drawn sharply back into the popliteal space by the

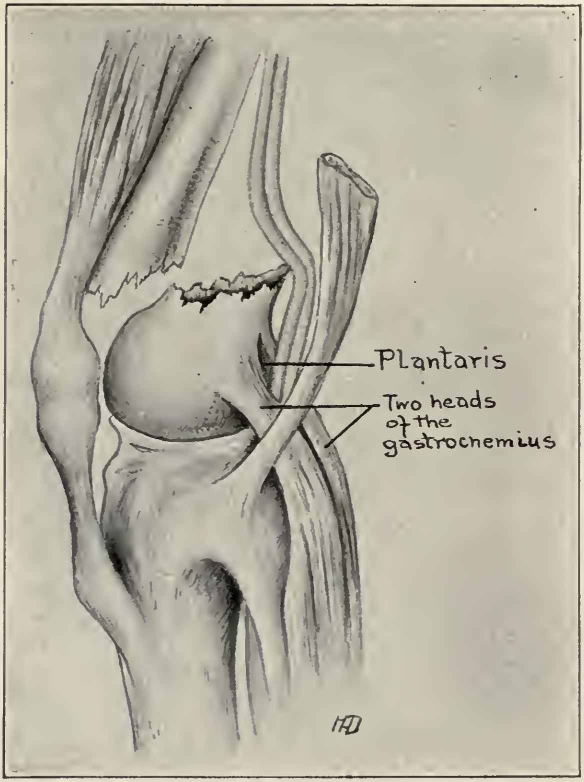

Fig. 24.—Supracondylar fracture of the femur. The lower fragment is seen to be drawn back into the popliteal space by the gastrocnemius and plantaris. The vessels are stretched over the sharp edge of the lower fragment.

gastrocnemii muscles; much damage may be done by the sharp edge of the bone to the popliteal vessels. (Fig. 24.) The site of the fracture, its obliquity, the pull of these various groups of muscles, the iliopsoas, the adductors and the glutei especially have much to do with displacements,

and the long flexors and extensors have to do with the upward pull of the lower fragment and shortening. These forces must be duly considered, not only in making the diagnosis, but in using the proper appliances to secure restoration and union.

In the subsequent chapters both the old and new appliances designed to assist in securing anatomic and functional restoration will be considered. To get a proper estimate of their worth, these mechanical laws and anatomic facts must ever be borne in mind. Do not let this be the whole thought; but ever remember that we have to do with conscious living human beings, not merely an insensate skeleton. Remember that we have muscles, vessels, and nerves which demand as much care and consideration as the broken bone; and do not forget the patient himself—both a physiologic and psychologic entity—whose rights and every function should have due consideration.

CHAPTER III

SPLINTS FOR IMMOBILITY

Verbal camouflage is not infrequent in medical writing and talk. "The patient is doing as well as could be expected under the circumstances," is as old and nonsensical as anything imaginable; but we have often seen it pass for wisdom. So, certain words are used quite as ambiguously as these trite expressions. They often convey an idea which at first was presumably correct, but in the light of later truth is seen to be false. This idea is unfortunately not only conveyed to the laity, but continues as an impression with the profession as fixed as it is false.

Such a word is "set" as used when "the surgeon was called to *set* the bone." "Setting" the fracture is an expression found in texts old and new, as well as in the country vernacular. The popular notion is that "setting" is the most important procedure in treating a fracture; if the bone is "set" right the outcome will be favorable; if wrong, it will be more or less disastrous.

Long discussions have taken place about the proper time for the setting as to whether it should be done immediately or after some days. The word "setting" so used has the idea of finality about it, and implies that when the act is done, and the setting secured by immobility, the surgeon may sit by for a few weeks with the sweet consciousness of "having done all that was possible for skill to do." The limb treated may be shortened, angular, even functionless. It may be atrophied

and paralyzed, notwithstanding the skillful setting. Now the old idea of setting the fracture was that the ends of the bones were to be put in apposition and restored to their previous alignment. This was the guess of what had been effected in those cases where the limb was restored to comparative symmetry. Covered by abundant muscles as is the thigh, there might be displacement or even overlapping of bone fragments; but it could not be discovered. In the later experiences of operative work, and through the use of the x-ray, we have discovered how infrequent a perfect setting is. We see now how difficult and unusual it is to get perfect alignment, especially with the use of the older methods of simply reducing the fracture, and trying to fix it in reduction.

"Reduction" and "retention" are somewhat better words, with not so much finality as "setting" but they are by no means the *last words,* as some would think.

If reduction is incomplete, retention only helps to secure that incompleteness. Heretofore we have said that the treatment of fractures was mainly a mechanical proposition, and a proper understanding of physical laws and the application of force were very essential for the successful treatment of fractures. This does not mean, however, that we may regard a fractured femur as a carpenter would a broken chair leg, and proceed to splint it with sticks, bound to the leg. It has been stated before that there are other vital parts to be considered than the bony framework. The classical treatment of fixing the joints above and below the fracture goes further to indicate the difficulty of fixing the bone firmly in place. It goes further, also, in increasing the difficulty of restoring function later. Now, when we go still further in our "classical" efforts, and apply our immo-

bility apparatus with beautifully fitting bandages, we may sit back and admire the work of surgical art. We may have covered the limb beautifully but too tight, and with disastrous results. We may have covered it beautifully, and soon it is too loose, with a loss of what alignment we may have had. We have disregarded the whole patient by confining him in our instrument of torture, more burdensome than stocks. We have disregarded his nerves, his muscles, and his skin. We have forgotten his poor joints. We have done nothing but fix his bone imperfectly, and we have left kind nature much handicapped, to accomplish the nearly miraculous, as, indeed, she often does. Why this dissertation? It is because all old methods are not good methods and things "classical" need not be reverenced; but because they should be questioned as science progresses. This is not the age of medical and surgical empiricism, it is an age of progressive medical science.

But to say this, is not to declare that "setting" the bone is not modern, and "splinting" the fracture has no place. Both procedures are of the utmost importance; but are not *all.*

At this point I shall call attention to the simpler, primary, and perhaps primeval forms of splinting, and shall indicate their best possible uses now, as applied to the fractures of the femur. Archæologists find evidences among prehistoric peoples of the use of splints, fashioned usually from bark or wood. We make our splints from a multitude of stiff materials: wood, metal, plaster, leather, paper, fabric with silicon, starch, etc. The simplest and handiest material is usually wood, which has the requisite lightness and strength, and can be padded to fit the curves of the body. Plaster of Paris

is probably the next most used material on account of ease of handling and its perfect adaptability to the curves of the body. Perforated metals, wire and other materials all have their uses and are chosen by different surgeons, according to their skill in applying them. Nature herself splints with spastic muscles and with loss of function. She often does well as to functional restoration, but she is not so successful in preventing angulation and shortening. She produces no Volkmann's contractures, ankylosed joints and such like. We recently saw a kitten with a fractured femur lying quietly with spastic muscles for several days; in two weeks she was climbing a tree.

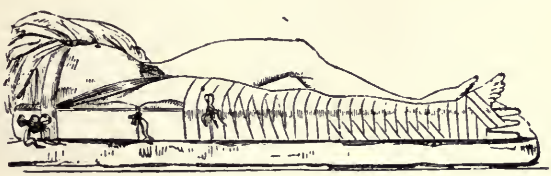

Fig. 25.—Liston's side splint, perineal counterextension. (Hamilton—*Fractures and Dislocations.*)

If a surgeon should be called to see a fractured femur, his first duty would be, after making the diagnosis, to transport the patient safely to bed. A splint to immobilize and prevent further injury would be necessary. What better could he do than find a board and make the old Liston splint? (Fig. 25.) What worse could he do, after he had the patient home, than leave him tied to it? There he would be, bound to the stiff straight stick, with ankle, knee, and hip all immobile (surely classical), and with a perineal band pulling from the top end of the board in a vain endeavor to produce some extension. The extension that might be produced in this way is so little that it is worthless. Or, perhaps one may think

the condition of the patient would be improved if, after getting him home, he were put in a similar board bound to his side from below the foot to near the axilla with extension made by a weight and pulley (Fig. 26).

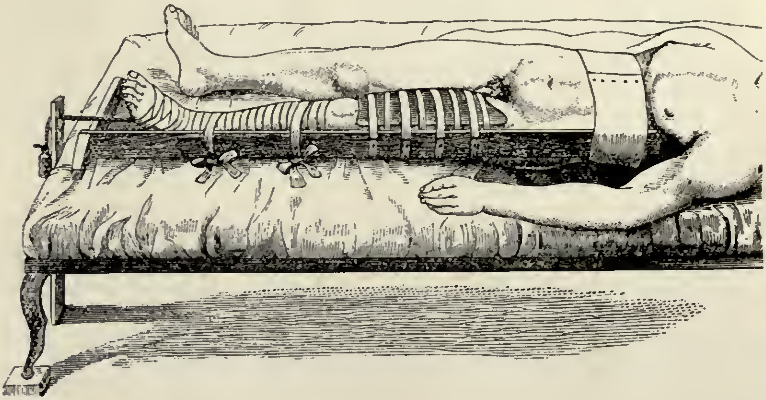

Fig. 26.—Hamilton's dressings for fracture of shaft of femur, complete. The long splint extends nearly to the axilla. (Hamilton—*Fractures and Dislocations.*)

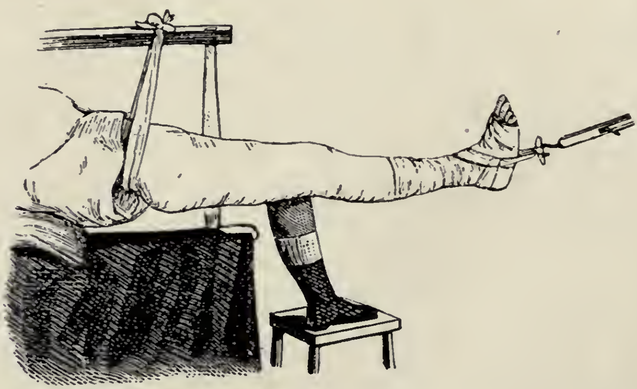

Fig. 27.—Extension continued until the plaster is hard. Hamilton—*Fractures and Dislocations.*)

Hamilton says that "during the first four or five weeks the patient should not be allowed to rise or sit up in bed." Also: "It is an error to suppose that such re-

straint is irksome. In my experience, no patient has ever complained of it." We wonder if these patients felt that they were entering the first circle of Dante's *Inferno* and were led to exclaim: "Through me you pass

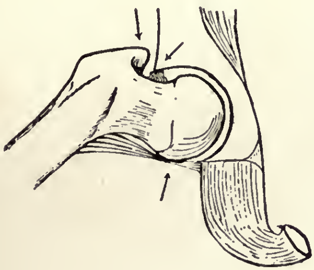

Fig. 28.

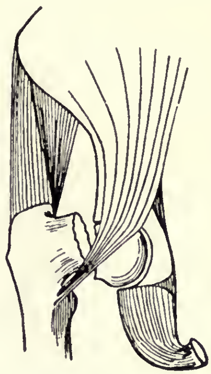

Fig. 29.

Fig. 28.—The range of normal abduction limited by contact of bone and by tension on the capsule. (Whitman—*Orthopedic Surgery.*)

Fig. 29.—Fracture and displacement. (Whitman—*Orthopedic Surgery.*)

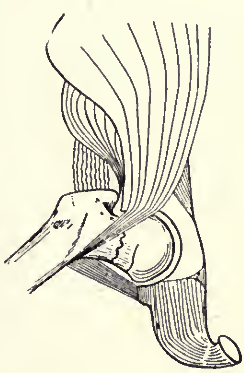

Fig. 30.—Reduction by the abduction method. (Whitman—*Orthopedic Surgery.*)

into eternal pain. . . . All hope abandon ye who enter here." "Restraint" and "irksome" are mild words.

The extension so necessary but so modified by the

board and bed as to be an unknown quantity is really not worth considering.

The application of a plaster of paris splint under extension (Fig. 27) for fractures of the femur perhaps makes it more possible to "set" the bone accurately than almost any other immediately applied splint.

Those who use plaster skillfully can do much with it. Satisfactory extension is not obtainable in so muscular

Fig. 31.—Fixing the limb in complete abduction and extension. (Whitman—*Orthopedic Surgery.*)

a member as the thigh. Shrinking of muscles soon takes place; the splint becomes loose; reapplication is necessary; and coaptation is not secure. The weight is burdensome. Mobility is increased and bed care easier than in a Liston splint. Immediate application is dangerous on account of possible increased swelling and strangulation. For a properly reduced transverse fracture of the femur shaft, there could be nothing much better than a plaster splint. It is not so suitable for fractures of the

neck, although it may be used to advantage in children, as suggested by Whitman (Figs. 28, 29, 30, and 31).

The diagnosis and the position of the head of the femur, after splinting, should be accurately verified by the x-ray. The extension factor in this complete abduction position is not so necessary, as the axis of the shaft is directed against the ilium and the trochanter impinges thereon preventing the upward displacement and shortening. Otherwise, this splint has all the usual objections

Fig. 32.—Cast of lower extremity and trunk applied with the thigh and leg flexed to right angles. This form of cast is of great advantage when the hip is fractured in elderly persons who are unable to stand the recumbent position. During the day the patient may be placed in the sitting position, while at night he may lie on his back with the injured member properly bolstered. (Preston—*Fractures and Dislocations.*)

of plaster, and should be used only when position is verified by x-ray, and in children.

The application of plaster with the thigh and leg flexed at right angles (Fig. 32) is ingenious, making it possible for the patient to sit up, although both hip and knee are immobile. It also puts the muscles more at rest than when the limb is extended. Elderly persons, however, should never be incased in this much plaster. Even if

this position, and the change in getting up, prevents hypostatic pneumonia, it is certainly working blindly to have no chance to inspect their soft parts and care for them.

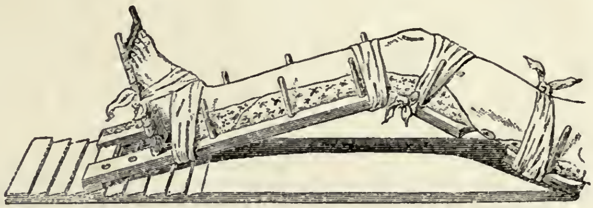

Fig. 33.—Double-inclined plane. (Hamilton—*Fractures and Dislocations.* After Esmarch.)

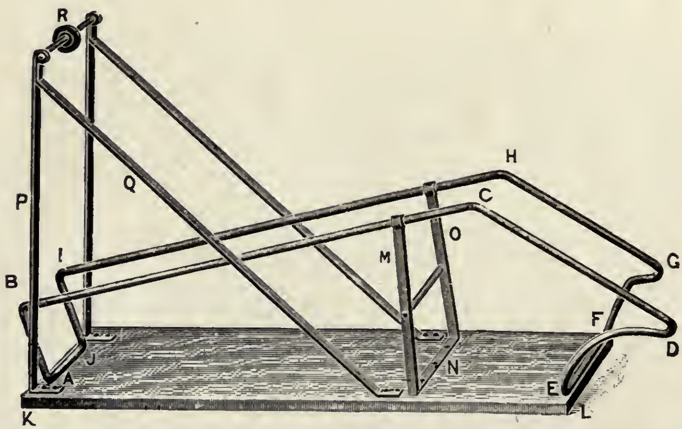

Fig. 34.—Wire cradle leg splint, for transport or extension. The splint is constructed of mild steel wire, ¼ in. thick, fixed on a board as shown. The two flat steel uprights bearing the pulley wheel can be screwed to the board if required, so that extension can be used without moving the limb from the sling splint. The model shown is for the left leg.
AB, JI-5 in.; *BC, HI*-30 in.; *CD*-15 in.; *HG*-13 in.; *DE*-7½ in. (cord of the arc); *EF*-10 in.; *CH*-8 in.; *BI*-5 in.; *P*-22 in.; *Q*-31 in.; *KL,* board, 34 in. by 9 in.; *MNO,* flat steel support; *R.* pulley-wheel. The bend of the splint at *C* and *H* is 11 in. above the board. (Groves—*Modern Methods of Treating Fractures.*)

This double-inclined-plane principle is valuable, however, not so much in fractures of the neck of the femur, as for the supracondylar fracture. It puts the muscles at physiologic rest, and this is a very important factor. Allowing mobility of the patient is a great advantage in

the aged, but this is more than offset by the disadvantage of being covered completely. Using the double-inclined plane of Esmarch (Fig. 33) padded properly, with the leg fixed to the distal plane, and the thigh plane slightly longer than the thigh, very fair extension may

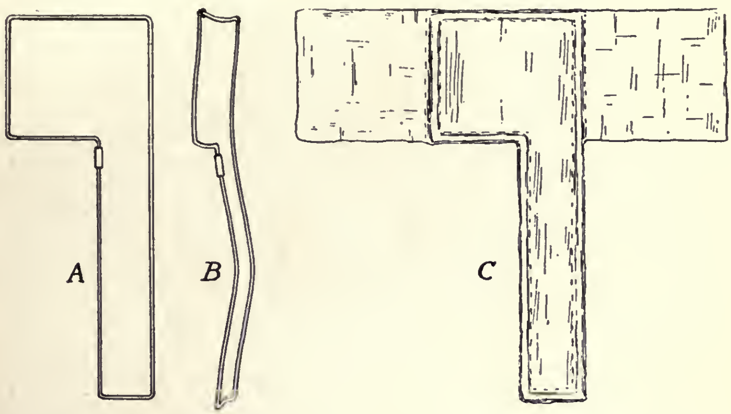

Fig. 35.—Cabot posterior wire hip splint. *A.* Wire bent to make splint. *B.* Side view showing bends to conform to the posterior surface of the lower extremity and hips, with knee in a position of slight flexion. *C.* Splint covered and lateral flaps attached to encircle the trunk. (Preston—*Fractures and Dislocations.*)

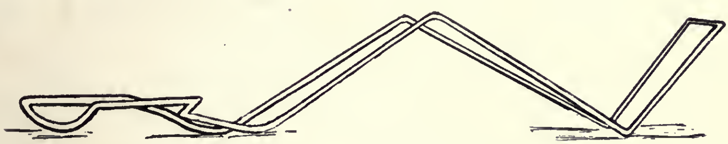

Fig. 36.—Cabot posterior wire splint bent to be used as double-inclined plane. (Preston—*Fractures and Dislocations.*)

be secured with physiologic flexion, which makes for comfort. This is a favorite method of treatment with many surgeons. Additional extension may be made in conjunction with this apparatus, either by pulley and plaster or Steinmann's pin. In this apparatus the patient is not mobilized, but fixed to his apparatus and the bed.

An adaptation of the double-inclined plane by using slings on a wire framework has been devised by Groves (Fig. 34) which seems admirably suited for applying this principle of treatment. It is also more suitable for the treatment of compound fractures, on account of the ease in dressing and irrigating. These splints are use-

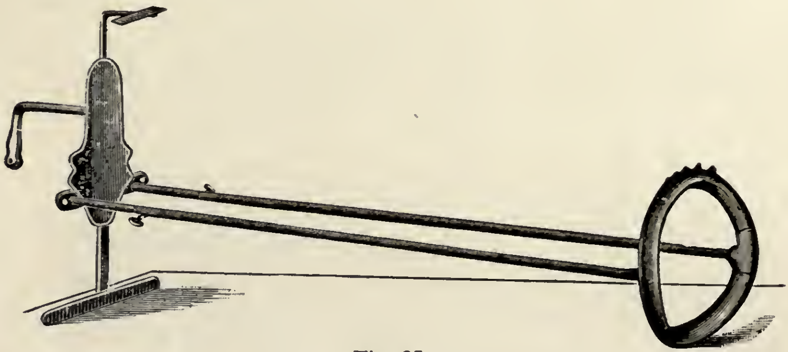

Fig. 37.

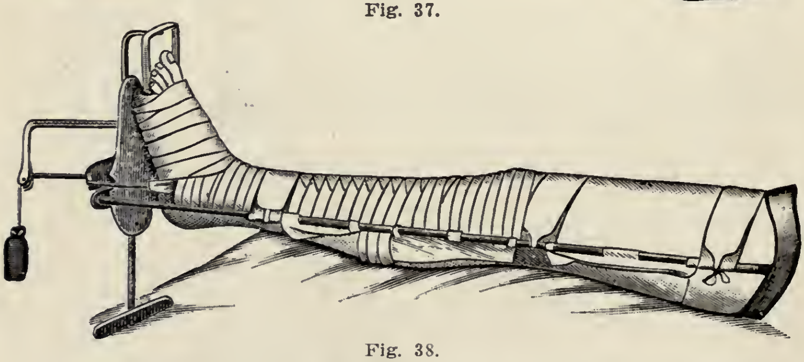

Fig. 38.

Figs. 37 and 38.—Von Bruns' combination bed and ambulant splint. (von Bergman—*System of Surgery.*)

ful as first-aid appliances for transport as well, and are giving very efficient service in war work. A suspension is secured in the double-inclined plane, but not the mobile suspension so ideal as is later to be described. These splints properly come under this classification of the kind producing fixation and immobility with little or

very limited extension. Another splint for securing fixation and immobility, one that can be made in the shape

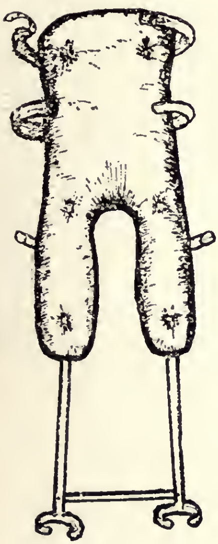

Fig. 39.

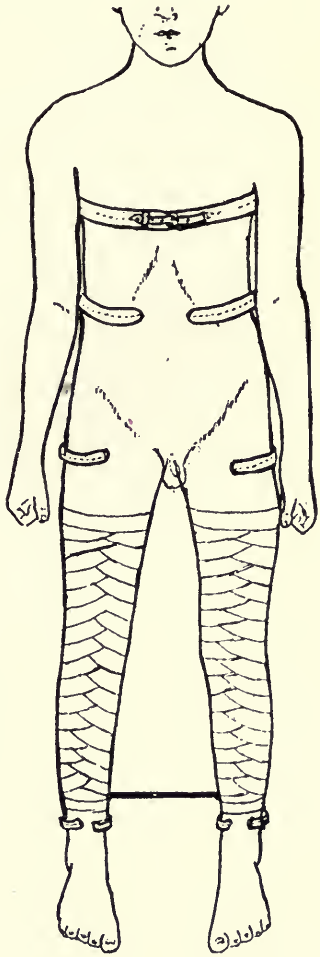

Fig. 40.

Fig. 39.—Thomas' double frame. (Jones—*Military Orthopedics.*)
Fig. 40.—Thomas' double frame applied. (Jones—*Military Orthopedics*)

of the double-inclined plane, is the Cabot posterior wire splint (Figs. 35 and 36). This is also suitable for trans-

port, and is more especially adapted for use with children. No other additional advantage is secured.

Fixation and physiologic muscle rest may be obtained with open treatment of the muscles, but there is insufficient extension, which is the most essential factor of all in treatment. Certain wire splint frames, with fixed rings extended around the hip and making limited extension, such as the von Bruns and the Thomas knee splint (Figs. 37, 38, 50, and 51), preferably, are classified under this heading. They are of great advantage, in that they may be made ambulant and used for transport; but they are very objectionable on account of the perineal or ischial pressure that may be produced if a sufficient amount of extension is secured.

Another kind of apparatus coming under the classification of fixation without extension is Thomas' double frame, which is very useful in transport (Figs. 39 and 40). Jones' modification of this frame for abduction and for making extension is a valuable addition to this splint, but hardly makes it of general practical use for permanent treatment, and scarcely removes it from a classification under "instruments of torture."

CHAPTER IV

SPLINTS FOR IMMOBILITY AND EXTENSION AND SPLINTS FOR IMMOBILITY AND AMBULATION

The three following chapters which precede the chapter explaining the Hodgen extension suspension splint, are for the purpose of analyzing the several important principles entering into the treatment of fractures of long bones, especially the femur. It is true the importance of these several principles is a matter of varying opinion with surgeons, as they are also relatively of different importance according to the bone involved, and the individual to whom the bone belongs. In the treatment of long bones with heavy muscles, such as the femur, there is one principle of treatment of relatively greater importance than all others, which cannot be too much accentuated, and that is extension. There are many factors of greater or less importance, as the case may be, but there can be no successful treatment of a fractured bone as heavy as the femur without sufficient extension. The fracture may be reduced or set, but it is very unlikely to stay so without the extension. Side splints may immobilize the bone at the point of fracture, but they will not overcome the strong muscle action that shortens the limb and makes the fragments overlap. Suspension may add to the comfort of the patient in bed, or he may have a splint in which he can go about on crutches; but, without sufficient extension, there will be shortening and deformity, and proportionately bad

functional results. Extension, then, is the application of force to counteract the strength of the long muscles pulling in the direction of the axis of the bone which makes the bone overlap and shortens it. We must have extension and counterextension, often under anesthesia, when we endeavor to reduce the fracture and put the bones in proper apposition. As soon as anesthesia passes, the muscles again become spastic, and all the force is exerted to displace the fragments. The rational kind of extension force to be applied is that which is continuous: something exerting a strong, steady, continuous action, which finally overcomes the tired muscles and keeps them in subjection. This force should be a more or less definitely known quantity. It should be something which can be measured. To be ideal, it should be exerted on the limb alone, and not be modified by friction on bed or apparatus, using up thereby an unknown and varying quantity of the pull. It will be found by experience that much less weight is necessary when it acts continuously and is used in conjunction with a freely mobile fixation apparatus.

Of course, extension implies counterextension; for man is a movable body. It seems stupid, indeed, to construct elaborate apparatus to make counterpulls when the attraction of gravity is continuously acting, and all to be done to get that force is to elevate the foot of the bed to the requisite height.

Now, in applying extension and counterextension, we do not ordinarily apply our forces directly to the bone itself, but to the muscles and overlying soft parts. True, it is the axis of the bone that must be elongated, so that the ends may come into apposition; but it is the soft muscles that are contracting to prevent that apposition.

Forces may then be applied through the skin and fascia to the muscles to stretch them, or we may transfix the bone and exert the force through the bone to stretch the muscles, or as the older method was, apply the force to the foot, pulling through the entire distal portion of the limb. In the previous chapter, which considered the anatomy of the thigh, we have noted the fascia lata and its attachments and relationships. When this great fibrous sheath is properly stretched, the muscle, bone, and other structures tend to resume their proper relationship. Indeed, when stretched, it acts as a splinting agency to both muscle and bone, and this fact goes to show still further the great value of this principle of extension in fracture treatment. By this single agency alone, or in conjunction with sand bags or pillows, the limb may be sufficiently immobilized to get the best results; and indeed this method of Buck's extension, and a few side splints of metal or wood or plaster, has been for years the most popular one.

The older methods of making extension through the foot by a cravat or shoe top (Figs. 41 and 42) still have their uses, and are the easiest in application for use in emergency splints for transport, making sufficient extension temporarily. But for continued use they are not so good; because the force is transmitted through the knee joint, muscles, and ligaments, doing damage ultimately by overstretching them. Since our great Civil War, adhesive plaster has come into general surgical usefulness. Gurdon Buck it was, who popularized its use in making extension. He applied it in the treatment of fractured femurs with great success, and popularized it so that it not only bears his name, but actually enters into the application of practically all the efficient meth-

ods of treating fractured femurs. An old print (Fig. 43) will show his original method, and indicate how closely he has been followed. In applying the adhesive plaster, the principle to be observed is to get the maximum amount of adhesive service possible by extending the plaster above the knee to the site of the fracture.

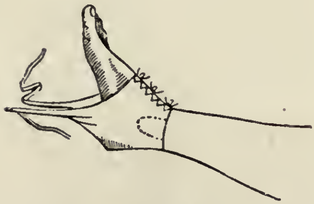

Fig. 41.

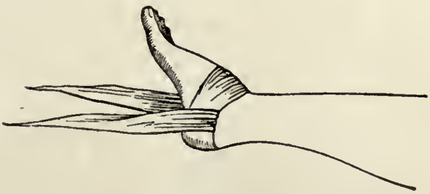

Fig. 42.

Fig. 41.—Mode of making extension with the gaiter. (Wales—*Surgical Operations and Appliances.*)

Fig. 42.—Mode of making extension with the cravat. (Wales—*Surgical Operations and Appliances.*)

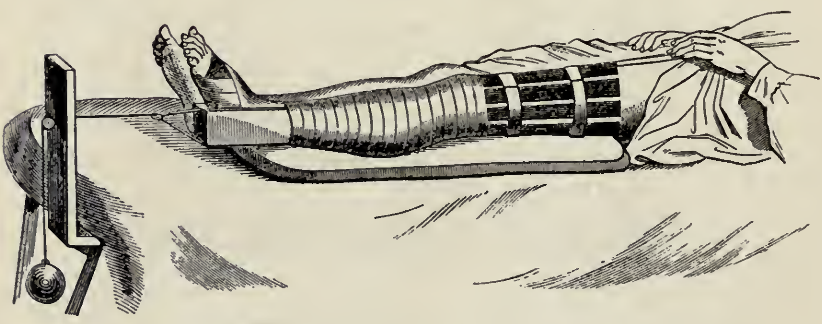

Fig. 43.—Buck's apparatus. (Wales—*Surgical Operations and Appliances.*)

This pull is transmitted through the plaster to the skin and fascia, stretching it and elongating the limb usually to the requisite length. The plaster should not stop below the knee, for the same reason that traction from the foot is not best. Indeed, some authorities extend it on the thigh the entire length and even above the fracture,

because the plaster does stretch, and that length of plaster will stretch as much as the fascia and skin. It will thus give a greater attachment for weight pull and also act as additional side splints helping the fascia.

The more modern method of securing extension by applying the force directly through the bone has its enthusiastic advocates. From a mechanical point of view, it would seem the best method of all. The firm bone gives a much more stable point for the application of the

Fig. 44.—Steinmann's pin introduced through condyles of femur for fracture of the shaft. Ligaments of knee joint are not stretched and movement at knee is not prevented. (Binnie—*Operative Surgery.*)

force. Even with this method we must remember that it is the stretching of the muscles and fascia that really does the splinting and brings the ends of bones into apposition; for without that support the bone would have no tendency to go into its proper place. With the knee joint as a fulcrum, the force applied above would pull the bone either hinging forward or backward as the pull

may happen to be either anterior or posterior of the center. The stretched fascia and muscle prevent this displacement just as it does when the force is applied through plaster externally. This extension no doubt has definite indications for its use. The occasion when it would seem to be most useful, when mutilation of soft

Fig. 45.—The crude calipers, constructed from meat skewers.*

parts makes plaster extension difficult, is when its use seems to be not indicated on account of dangers of infection. In the application of Steinmann's pin (Fig. 44) great care must be taken to prevent infection and in transfixing the bone care must also be used in drawing up the skin toward the seat of fracture, so that in exten-

*From Besley: Jour. Am. Med. Assn., Jan. 12, 1918.

sion the skin may not be stretched and become painful. Modifications of this idea are prevalent; and from the fact that the condyles of the femur are so large, and offer such advantageous points for calipers to pull, the apparatus of Besley (Fig. 45), which is an ice hook clamped in above the condyles of the femur, would seem

Fig. 46-A.—Groves' horseshoe screw clamp for grasping a bone without transfixion. This type has simple drill points. (Groves—*Modern Methods of Treating Fractures.*)

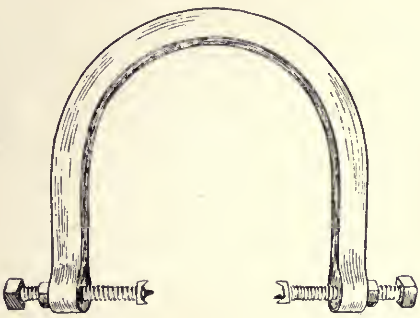

Fig. 46-B.—Groves' horseshoe screw clamp for grasping a bone without transfixion. The points of the screws are triple, on a swivelled plate which adapts itself to the surface of the bone. (Groves—*Modern Methods of Treating Fractures.*)

to be of much merit. It should have a lock screw to make it more secure. Better, perhaps, is Ernest W. Hey Groves' horseshoe clamp (Figs. 46 and 49) which screws into the bone a short distance, and is fixed there by a set nut which prevents the screw loosening. However, in a great majority of cases, there can be no good reason for its use; it is questionable if it is more me-

chanically efficient than adhesive plaster; and it is undoubtedly more dangerous, as the reports of trouble from it will show.

To return to the fact of the general recognition of the value of the extension principle in fracture of the femur treatment, we observe that the majority of appliances make effort to use it to greater or less extent. They are efficient in so far as they succeed in using this principle.

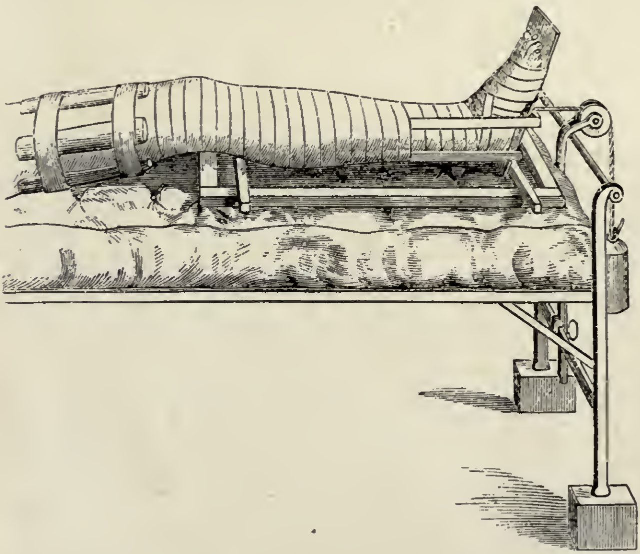

Fig. 47.—Volkmann's sliding rest. (Hamilton—*Fractures and Dislocations.*)

Also, most of the appliances use the adhesive plaster method of extension.

To improve the Buck's extension, we have Volkmann's sliding rest shown in Fig. 47. This sliding cradle on a frame permits the leg to move up and down without friction on the bed, thereby getting the full pull of the weight. It was an effort toward making the extension more efficient; and it does serve that purpose; but it evidently would not materially increase the comfort of the

patient. For an example of German efficiency, we might note the illustration of Helferich's extension splint (Fig.

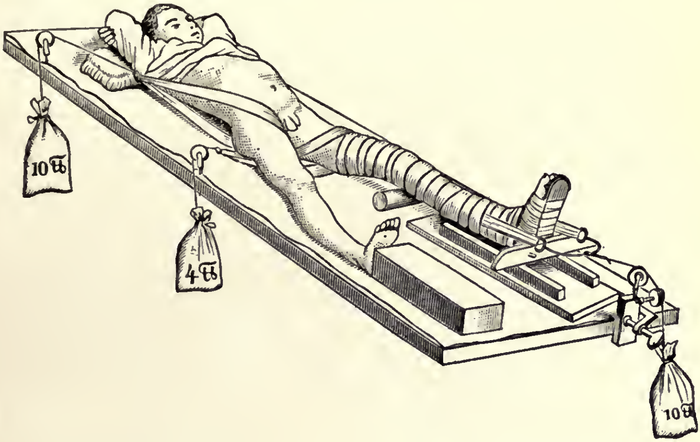

Fig. 48.—Helferich's extension splint. (von Bergman—*System of Surgery.*)

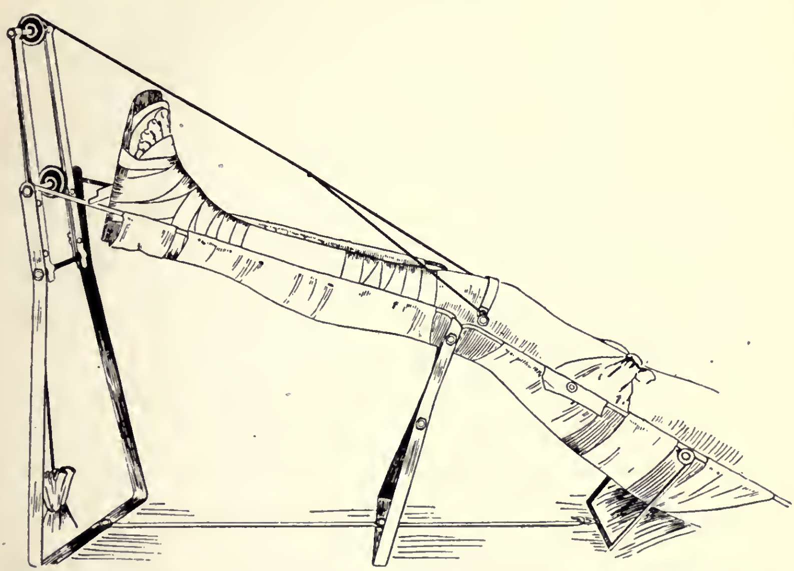

Fig. 49.—Extension by transfixion or by horseshoe screw clamp, the leg being supported on the Groves' wire cradle splint. (Groves—*Modern Methods of Treating Fractures.*)

48). Here, surely, was the ultimate to the German mind. Extension made by Volkmann's sliding rest, counterex-

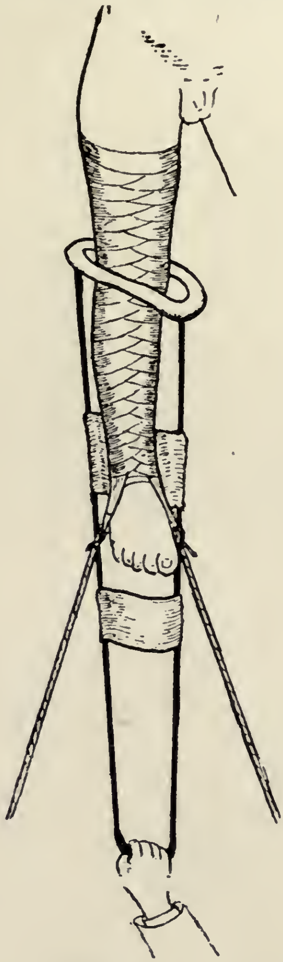

Fig. 50.

Fig. 51.

Fig. 50.—Introducing limb through ring of Thomas' knee splint. (Jones—*Notes on Military Orthopedics.*)

Fig. 51.—Knee splint in position, traction applied. (Jones—*Notes on Military Orthopedics.*)

tension through his perineum, a sidewise pull by another pulley preventing abduction of the upper fragment. If

we now might add a vulture clawing at the patient's vitals we would have a good picture of Prometheus bound. What unreliable advice has been given by some old writers!

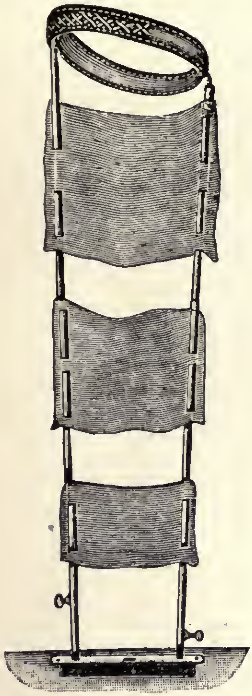

Fig. 52.

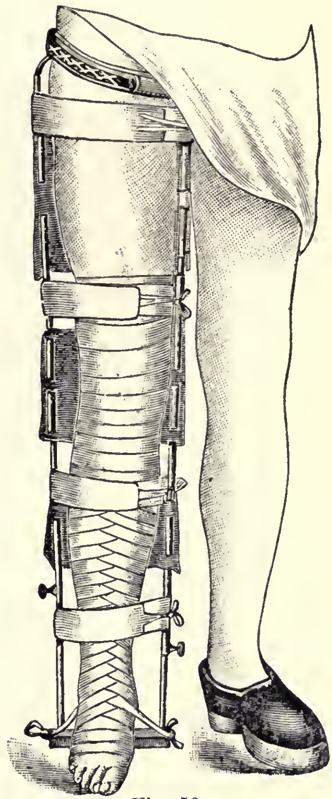

Fig. 53.

Figs. 52 and 53.—Von Bruns' splint when ambulant. (von Bergman—*System of Surgery.*)

Contrast with this apparatus Grove's wire cradle splint (Fig. 49); although the same principle of extension is shown to be the main factor, at a glance we see the difference in comfort to the patient. The splint is elevated and the limb suspended in a sling, not mobile at

the hip, it is true, but the extension is applied in the most positive and skillful manner. It may be applied either to bone direct or to skin and fascia. Slight flexion at the knee and hip is secured, which is physiologic and

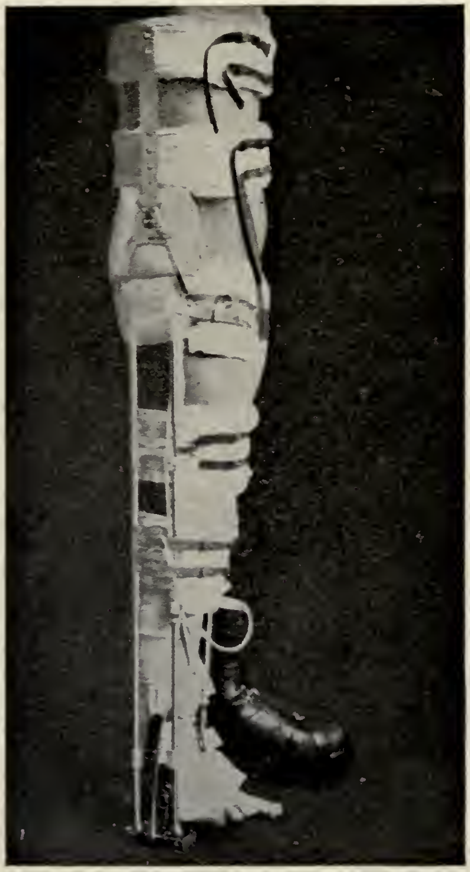

Fig. 54.—The ambulatory pneumatic splint with hip attachment. (Preston—*Fractures and Dislocations.*)

restful. The counterextension is secured by the limb resting on the inclined plane with the weight of the body at the lower end, open for inspection and care of soft parts or treatment of wounds. Surely a very great deal

is added to the comfort and general welfare of the patient. The wire splints seem to be becoming more popular, due, no doubt, to their greater usefulness in war surgery, and their advantage in dressing compound fractures. The extension principle is sometimes subordinated in such cases on account of the greater demands of the wound. Extension, however, is always of great value, and is not to be neglected. For limited extension the so-called Thomas knee splint seems most popular (Figs. 50 and 51). Counterextension is made by the metal ring around the thigh, pressing on the ischium. It seems to be much used as a first aid and transport splint, and serves its purpose well. Applying it necessitates putting the foot and leg through the ring, which is not so good as the Hodgen modified splint shown in Figs. 81, 82, 83, and 84 would be.

The same principle is used in the von Bruns' ambulant splint (Figs. 52 and 53), which depends for counterextension upon perineal pressure. This class of splints, however, serves an excellent purpose, although we sacrifice much by losing part of the extension.

Getting *up and out* is an element so important in some cases as to be the deciding one in recovery. Better save the patient, even if the leg proves to be short, than let the patient die with a full length leg.

The ambulatory pneumatic splint (Fig. 54) serves the purpose most admirably at times, and, when properly applied with the air-filled pads, is an apparatus of no great discomfort. It makes it possible to supply an element in treatment which is frequently a deciding factor between life and death.

CHAPTER V

SPLINTS FOR IMMOBILITY AND SUSPENSION

A principle of treatment of fractures of the femur that is of only slightly less importance than extension and immobility is that of suspension. To immobilize the bone, and extend it sufficiently to restore apposition and anatomic form, is of first importance, it is true, and should be secured whenever possible; but we have mentioned before that this is not only a mechanico-anatomic proposition in which we seek to restore the anatomy of the part by our appliances. We must recognize that we are dealing with a vital physiologic human being. Any means we may use to keep the functions of the patient normal and contribute to his peace of mind and general comfort are very useful adjuvants in his treatment, and go far toward restoring not only his anatomic form, but his functioning limb. The human body is normally a mobile body, and anything interfering with mobility is apt to interfere with various functions. Restraint produces a most depressing psychologic effect, which, in turn, has its effect on the patient's vitality. It is a geriatric principle that the muscles and organs of the old must be kept functioning so far as possible, else they permanently cease to function.

In treating the fractures of old people, this suspension principle is accordingly much more important than in treating the young. So much is added to the general comfort of the patient in the way of nursing and care that it becomes a very important factor. In our ana-

tomic considerations of the hip joint we must conclude that it is not only unnecessary but harmful to immobilize it. Indeed, it is harmful to immobilize any joint, if the adjacent fracture can be kept in apposition and immobilized without it. The ball-and-socket construction of the hip joint, so freely movable, does not need immobility, as it readily follows the pull on the fragment through a wide number of radii. This, then, allows this principle of suspension to be used, and also allows the free movement of the patient in the bed. We must regard as of great value the nursing and hygienic care of such a patient. When a patient is condemned to lie or sit in bed for some weeks, anything that adds to his comfort is really a vital factor in his recovery. The possibility of sitting up and moving from side to side in bed is a matter of great consequence, especially in the aged, and is often the determining factor in their recovery.

Hypostatic pneumonia is prevented, the evacuation of bladder and bowels is attended with much more ease, and the care of the skin, and prevention of bed sores, are all attained with ordinary care.

Another advantage secured by suspension is of much value in war work. The treatment of flesh wounds and compound fractures is made much easier when the limb is suspended in some suitable apparatus above the bed. Dressings may be applied with greater facility. The use of irrigating solutions and drainage is made easier. It seems that surgeons, if one may judge from their appliances, have put a widely varying estimate on the values of these several principles; some stress the importance of immobility alone; others recognize the great value of extension; and others, the good in suspension. We really need to know the true value of all these principles

and apply them in proportion to the demands which the case makes, when properly analyzed. One of the earlier advocates of the suspension principle was Nathan R. Smith. He constructed a wire suspension splint (Figs.

Fig. 55.—N. R. Smith's anterior splint. (Hamilton—*Fractures and Dislocations.*)

55 and 56) extending from the anterior spine of the ilium to the end of the foot with some bend for flexion at the hip, knee, and foot. This was placed anteriorly to the limb, and the limb was bound to the frame with rollers, the frame being suspended to the ceiling. This

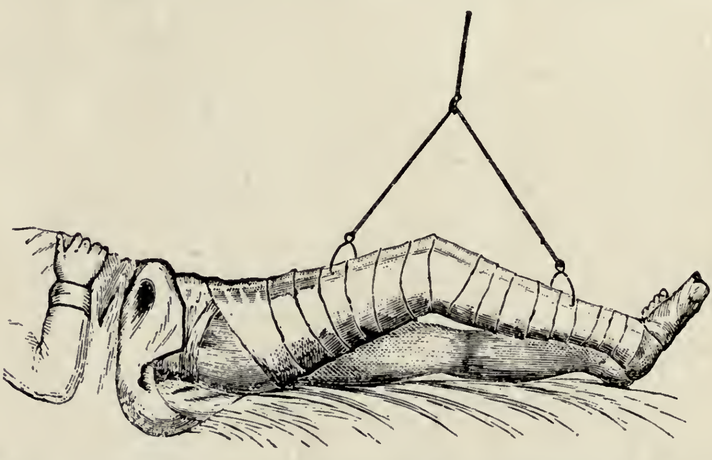

Fig. 56.—N. R. Smith's anterior splint, applied for a fracture of the thigh. (Hamilton—*Fractures and Dislocations.*)

splint was used extensively during the Civil War. It was possible to make some extension; but evidently the extension principle was not emphasized. Having the splint extend as high as the crest of the ilium interferes with flexion at the hip and sitting up in bed. It was, of

course, freely mobile and suspended high enough to make the care of the wounds easy. Another example of the

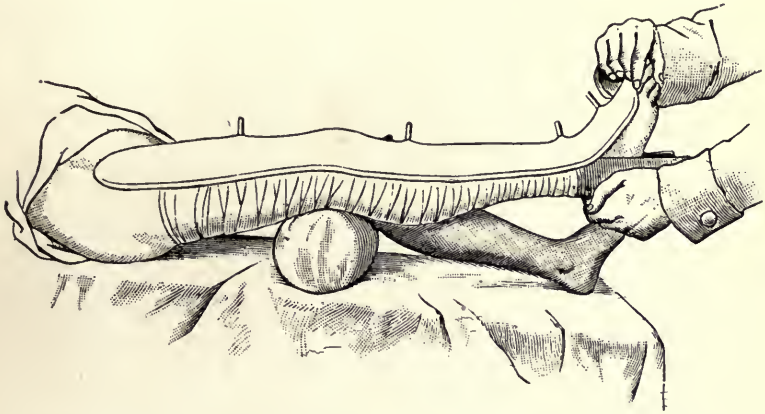

Fig. 57.—Beely's plaster of Paris strip splint with suspension rings. (von Bergman—*System of Surgery.*)

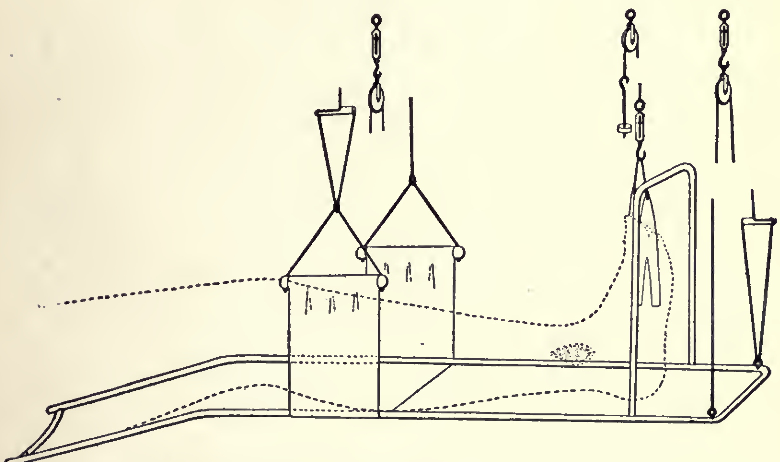

Fig. 58.—Modified Cabot splint for suspension and rotation in fracture of leg. (Stimson—*Fractures and Dislocations.* After Flint.)

same type of splint is Beely's plaster of Paris suspension splint (Fig. 57) provided with rings for suspension cords. The plaster form covers only the anterior part

of the thigh and leg from the groin to the base of the toes. The limb is bandaged to this and suspended. Any

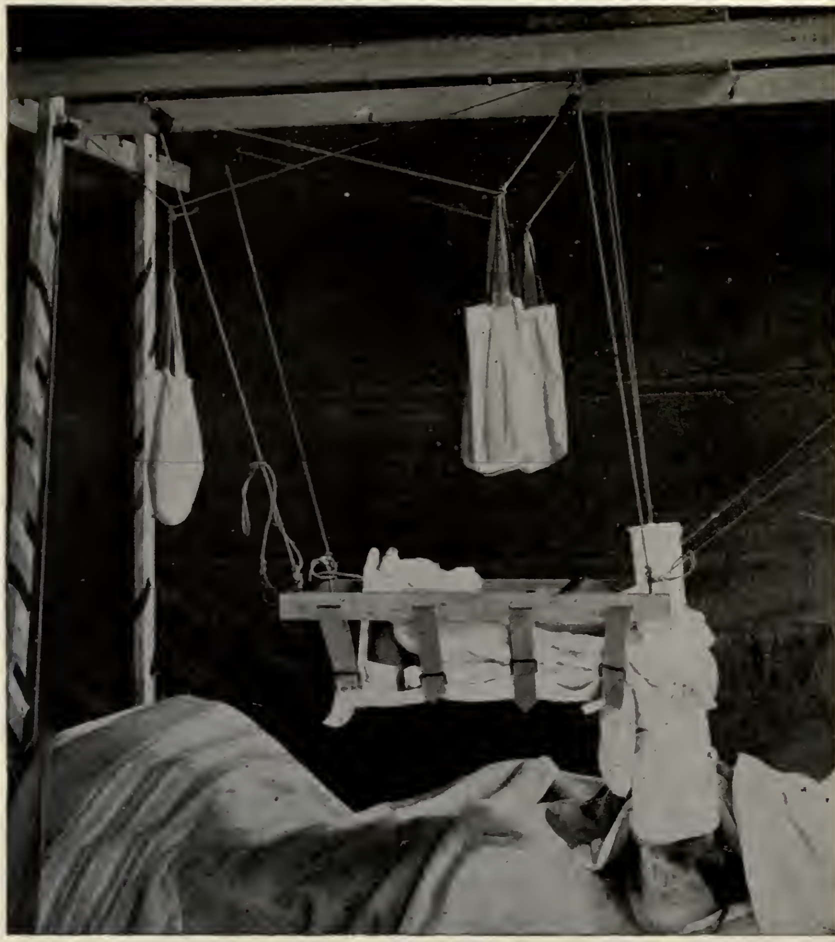

Fig. 59.—Showing the arrangement of the overhead extension apparatus used by the Pennsylvania unit in the treatment of an infected compound comminuted fracture of the upper femur with involvement of the pelvic bones. Continuous irrigation was practiced in this case. (Fauntleroy.*)

of the wire splint models may be used for suspension and fixation alone without extension. It is the usual

* Report on the Medico Military Aspects of the European War, Bureau of Medicine and Surgery, Navy Department.

custom to apply extension independently and not in the splint, as will be explained in the discussion of the Hodgen splint. The Cabot posterior wire splint, for instance, may be suspended with a device for rotation added, as will be noted in Fig. 58. Many intricate and elaborate forms of suspension are being devised in the present great war; for example, see Fig. 59.

Simplicity is sometimes almost synonymous with efficiency. Many valuable principles of treatment are often

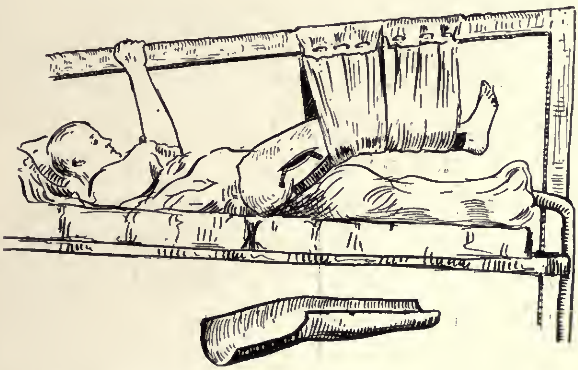

Fig. 60.—The Balkan splint. Fracture of femur and secondary hemorrhage from a branch of the profunda artery. The hemorrhage has been treated by ligature of the bleeding vessel and the wound has been packed with sacks of sterile salt. The posterior surface of the limb is supported by the metal trough shown in the figure. (Hull—*Surgery in War.*)

rendered less effective on account of the complex way in which they are applied. One of the chief reasons of, and the main desire in, this exposition of the Hodgen splint is to demonstrate its extreme simplicity as well as its efficiency. A more simple apparatus than that shown in Fig. 59 is the Balkan frame and sling (Fig. 60). We have no doubt that it is just as efficient for the cases described.

CHAPTER VI

SPLINTS FOR IMMOBILITY, EXTENSION, AND SUSPENSION

The appliance which will secure all three of the major principles, immobility, extension, and suspension, in the treatment of fractures, is the one that will prove to be of greatest value and nearest to the ideal. When all these cannot be secured, the next best must be some modification of necessity. The usual order of importance in sequence would be extension first, then immobility, and then suspension.

Extension first, because by extension we know we secure a great amount of immobility with it. The additional security in immobility is secured by splinting.

Suspension is less absolutely essential; but it is still such an important factor that it should never be neglected when it is possible to use it. Now, besides these three great principles, there are certain other considerations of importance that should not be neglected. Attention has been previously called to the ball-and-socket hip and shoulder joints. With a proper understanding of anatomy and of the functioning of these joints, we know it is not only unnecessary but often harmful to follow the classical rule of immobilizing the joints both above and below the fracture. The ball-and-socket hip and shoulder joints need not be immobilized; and from this fact we secure another advantage hardly of less importance than that of suspension, that is, the fact that the entire limb can be left mobile from the hip joint.

This adds very much to the patient's comfort and nursing, and is consequently a great desideratum. It is a thing of such value that, in the care of old people, these changes of position may be made so frequently that it is almost equal to being up and out. Another consideration of apparently minor but of really great importance is the position in which a limb is fixed; i. e., its relative position to flexion and extension. Stand erect in a jamming crowd for sometime with strained hamstring muscles, and how painful and tired they become. Stretch your legs for five minutes in complete extension and notice the consequent pain. We are born flexed; we sit flexed; we sleep in flexion; and a certain amount of flexion of the limb is perfectly natural and physiologic. To prevent this pain, and consequently this paralyzing effect on flexor muscles, any joint that must be fixed should not be fixed in complete extension, but should have certain degrees of flexion, approximating that which is as a rule most natural to assume, and therefore the most restful. The necessary flexion might most properly be called "physiologic flexion," and should always be taken into consideration in applying any form of splint. To have your assistant who is making counterextension on the patient's foot, support the limb only by the foot and extensive force when applying a splint, thereby making extreme extension of the limb, is very harmful. The muscles become fixed in this hyperextended position, producing pain and paralyzed muscles. To get the muscles at rest, the degree of flexion should not be less than twenty degrees. More flexion up to a right angle is not painful or harmful, but restful. Beyond that point, the extension muscles likewise begin to be stretched and are painful when fixed. Any fracture appliance that does

not take into consideration this normal flexion at hip, knee, and foot is greatly at fault. This care of muscles is of equal importance in securing future normal functioning, and therefore this is a thought which should not be forgotten. There are still other factors of importance in the ideal splint. These may be summed up in our estimate of the Hodgen extension suspension wire cradle splint, which nearest approaches the ideal, be-

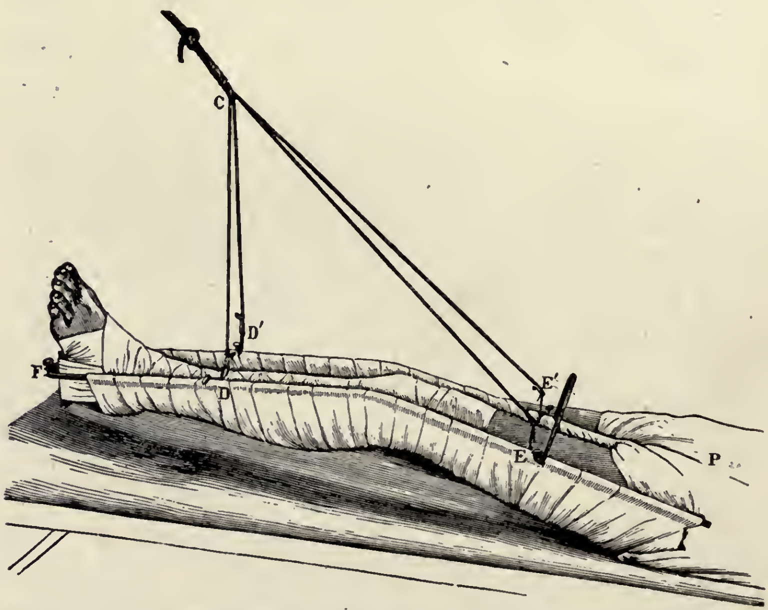

Fig. 61.—The Hodgen extension suspension splint. (See Figs. 62 and 63.)

cause it meets all the requirements we have been reviewing.

Let us consider the mechanics and the general principles of this splint, and see how well it meets all requirements. An old drawing (Fig. 61), fairly represents the true Hodgen splint. It shows the wire frame and the slings supporting the limb therein. The frame extends

from the perineum to two or three inches below the foot, transversely across the foot four or five inches, and externally as high as the trochanter of the femur. The slings are of domestic bandage, three or four inches wide and embrocated one half, making a smooth, even bearing from heel to perineum. The Buck's extension cord is attached to the crossbar under the foot. The suspension cords are attached to hooks midway between the knee-bend and distal end of splint, midway between the knee-bend and pubic end on the inside bar of the splint and exactly opposite on the outside bar. There is a bend of 20 to 30 degrees at the knee for physiologic flexion and perfect rest. The cords from these four points of support are attached to the suspending cord, which in turn is attached from a high point at the necessary inclination to make suspension and proper extension. The longer the radius of this suspension cord, the more mobile may be the patient. Therefore, the ceiling of the room is a very suitable point from which to suspend it. Now, to analyze these forces refer to Figs. 76 and 77, showing method of determining the amount of extension secured. Also refer to schematic drawings shown in Figs. 62 and 63.

F represents the foot; and *P* the pelvis; *FP* the axis of the limb; *FDE* represents the splint bars; *CD* and *CE* the suspending cords to the cord *C*, which is attached to the ceiling. Now if the cord *C* is vertical, we have simply suspension, which represents the weight of the limb, which in this case is 25 pounds. Now incline this suspending cord in the direction of the axis of the limb, until the pull represents 50 pounds. Then, of course, we still have 25 pounds suspending force, representing the weight of the limb, and an additional 25 pounds resultant

force, which pulls longitudinally, making that much extension. In other words, *FDE*, the splint bars with at-

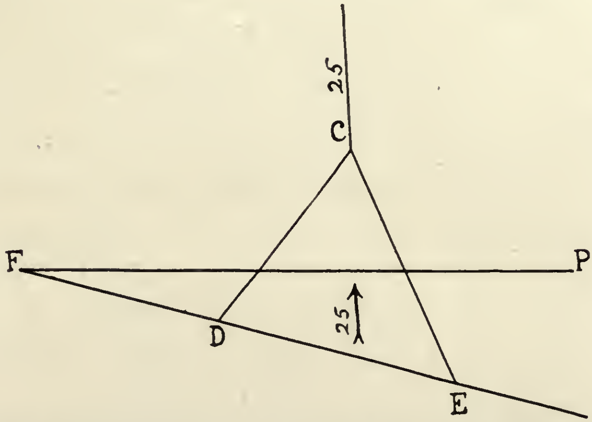

Fig. 62.—Schematic drawing of Hodgen splint vertical suspension. *FP* represents the limb; *F*, foot; *P*, pelvis; *FE* represents the splint; *C*, suspending cord, suspending vertically; *CD* and *CE*, cords suspending the splint. The vertical lift is 25 pounds distributed evenly along the limb. This is the suspension force. There is no extension.

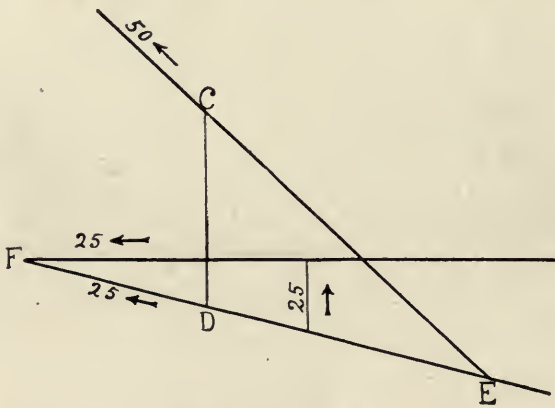

Fig. 63.—Schematic drawing of Hodgen splint extension and suspension. *FP* represents the limb; *F*, foot; *P*, pelvis; *FE* represents the splint; *C*, the suspending and extending cord; *CD* and *CE*, cords suspending the splint. A pull of 50 pounds at *C* still makes a suspension of 25 pounds and an extension at *F*, the foot, transmitted to the limb of 25 pounds. *FP* is the resultant force.

tached slings, pull upward evenly for the entire length of the limb the supporting weight of 25 pounds, and the

inclination pull puts a 25 pound pull at *F*, the foot, or fulcrum, which is transmitted through the limb to extend it. Therefore, it is readily seen that this extension force can be regulated to the desired amount by simply the amount of inclination in the suspending cord, as well

Fig. 64.—Hodgen splint suspended and extension made by a separate pulley. (Stimson—*Fractures and Dislocations.*)

as making this most comfortable suspension by that same cord. Of course the counterextension of 25 pounds is made easily by simply elevating the foot of the bed, so that the body gravitates toward the head of the bed.

We see, by this analysis, that by the application of a

single suspending cord we have secured all the important factors in treating a fracture of the thigh. We secure any degree of extension desired, in addition to suspension and immobility of the fracture. We secure also knee flexion, open treatment, and a movable, comfortable patient. One wonders, after analyzing the Hodgen

Fig. 65.—The calipers in position, and the Thomas knee splint slung by means of pulleys from the Balkan frame. Note that the pull on the calipers is in the direction of the long axis of the femur.*

splint, and learning its extreme simplicity, why it has never been popularized. Many surgeons are recognizing the great value of all the principles involved. They go far and make complicated apparatus to secure what is obtained in the Hodgen splint so simply: separate ex-

* From Besley: Jour. Am. Med. Assn., Jan. 12, 1918.

tension, separate suspension, ischial counterextension, and all the several combinations. Every modification of the Hodgen splint has detracted from rather than added to it advantages. There is no advantage in separating the two forces, suspension and extension, but rather a loss in mobility of the patient and the limb. The exten-

Fig. 66.—A simple method of suspension and extension of the leg. Patient from the Second Southern General Hospital with gunshot wound and fracture of neck of the femur. The uprights which support the horizontal bar can be attached to any bed. The pulley can be adjusted in height. The weight shown is 12 pounds of sand. (Groves—*Modern Methods of Treating Fractures.*)

sion being made from a fixed point, as in Fig. 64, is less mobile and less efficient. Any wire cradle type of splint may, of course, be suspended. The Thomas knee splint seems to be the favorite of all. Indeed, it is an

excellent splint, and no doubt very useful in first aid and transport service. The objection to its continued use must be the ring around the hip, even if it is not used as the counterextension push. Besley, Base Hospital No. 12, uses the suspended Thomas knee splint in conjunction with caliper traction. This splint is suspended overhead to a Balkan frame, and the traction on the calipers is made in the line of the femur (Fig. 65). This same traction may be made within the splint and

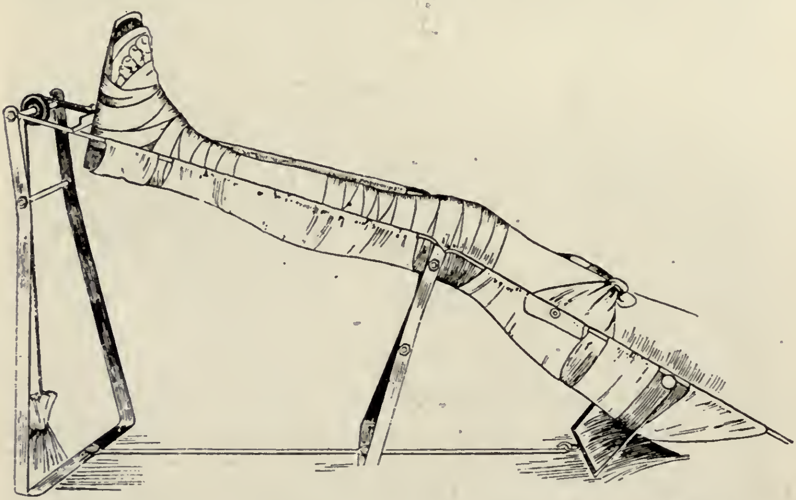

Fig. 67.—Groves' wire cradle splint in use. (Groves—*Modern Methods of Treating Fractures.*)

preserve the greater mobility of the limb. Another very simple and efficient method of suspension and extension is shown by Hey Groves (Fig. 66). This is to be commended for its simplicity. It is not so open as a Hodgen splint; not so capable of immobilizing the fracture site as the wire frame extension bar, but is most efficient. Mobility of the patient is somewhat sacrificed. If we sacrifice our mobility we may as well use Hey Groves' wire cradle suspension extension splint (Fig. 67), which

is a very excellent one. Schede's method of vertical suspension which is very excellent and appropriate for children (Fig. 68), embodies the principles of suspension, extension, and mobility, the counterextension being made by the weight of the body. For fractures of the neck of the femur, when abduction is needed, it fails to

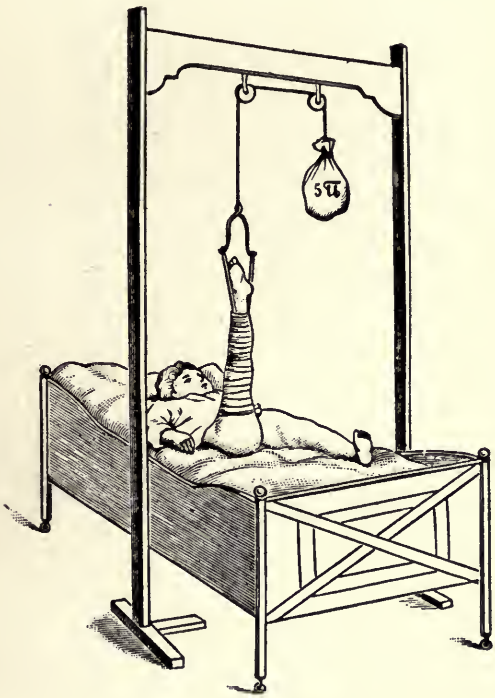

Fig. 68.—Schede's method of vertical suspension. (von Bergman—*System of Surgery.*)

give it. It also tends to hyperextend the knee, and, of course, is not open for wound treatment. Fig. 69 shows Blake's splint with the padded arch against the glutei (*5*) extension straps buckled to metal footpiece (*4*) supported by slings from the frame with two straps buckled over the limb. Now this may be suspended, and addi-

tional extension made. (See Fig. 70.) Separate traction is made by Buck's extension from the metal footpiece on the entire splint and limb. Suspension is made

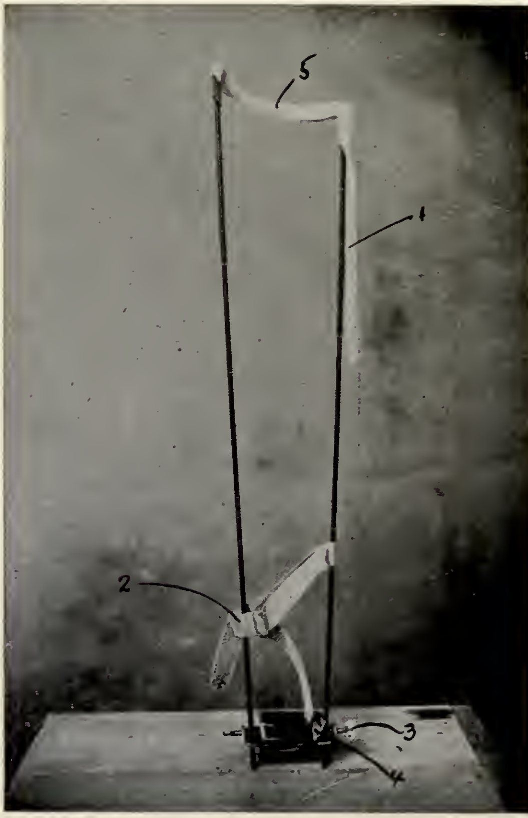

Fig. 69.—An improved model of Dr. Blake's splint for the right femur. (Fauntleroy.*)

by separate pulleys to a roller track above, to promote longitudinal mobility. Counterextension and suspension is made by another pulley from the splint on the thigh. Foot-drop is prevented by adhesive and a separate pul-

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* Report of Medico Military Aspects of the European War, Bureau of Medicine and Surgery, Navy Department.

ley for that purpose. It is all very admirable, and is a stupendous effort to secure the essential principles of extension, immobility, and suspension in fracture treatment of leg and thigh. Why should there be used so many more or less intricate mechanical pulls, when the Hodgen splint with one cord will do all and more?

Fig. 70.—Blake's splint showing weights and pulleys for separate extension, counterextension, and suspension, and weight and pulley to prevent foot drop. (Redrawn from photograph in New York *Tribune.*)

Then, to summarize the advantages of the Hodgen splint, it secures:

1. The application of extension and counterextension in a more effective way. No perineal or gluteal pressure being used to obtain counterextension; but it is secured simply by gravity when the foot of the bed is elevated. Extension is within the splint itself, and the freest mo-

bility is obtained because extension is not made from a fixed point.

2. With the sufficient extension and counterextension, and the cradle sling from the side bars of the splint, we secure, almost always without help of coaptation splints, a proper reduction of the fracture.

3. Suspension of the limb is obtained, which permits the freest movements of the patient and the limb, short of getting out of bed. This is an invaluable factor, especially in the aged, where confinement is so detrimental in making loss of function, and where the dorsal position would produce static pneumonia. The patient sits up, and moves, and turns about in bed, with the greatest freedom.

4. The splint is flexed at the knee, and flexion is made at the hip by the suspension. This assures muscle rest and relaxation, and contributes to comfort as well as to repair of the bone.

5. Various modifications of the splint, not in principle, but only in form, may be made to meet all the requirements of fractures and wounds from the pelvis to the foot.

6. The splint being open leaves the limb always under inspection and ready for the treatment of skin and muscle by massage and other appropriate care. This is a very important factor in the complete functional and early restoration of the limb.

7. For the treatment of compound fractures and septic wounds, it is most valuable, as drainage, irrigation and dressings may be applied easier than when lying in the bed or encased in bandaged splints or plaster.

8. For the routine examination by x-ray it is advantageous, as the patient may be moved into any desired position and the fluoroscope may be used from almost any angle. This routine examination will make it possible to give the proper amount of extension, suspension or abduction requisite for good apposition and union.

CHAPTER VII

THE HODGEN EXTENSION SUSPENSION SPLINT —PRACTICAL METHODS OF MAKING AND APPLYING—THE MATERIALS USED

When the surgeon thoroughly understands the indications to be met in treating the various fractures of the femur, the application of the Hodgen splint is simplicity itself. In fact, it requires much less care than the use of various other types of splints, and it is remarkable by what slight modifications we may meet every requirement for the proper treatment of any fracture, from the neck of the femur to the ankle joint. Even the mechanical part of fashioning the splint can be done by one inexperienced, and any ordinary blacksmith, with few directions, can make a splint. The so-called Hodgen splint from instrument stores, adjustable, extensible and polished, is usually imperfect, and all but worthless.

How easy it is to measure from the pubes to three inches below the foot, and four inches across the foot, and from this point to the top of the trochanter. The total length of these measurements will be the length of $\frac{3}{8}$ inch soft iron rod, to be cut from stock with cold chisel. Now measure on this rod the distance from pubes to 3 inches below the foot, and make a chalk mark; measure 4 inches further, and make a chalk mark. Now bend in the same direction from these two chalk marks at right angles. This can be done by hand, or with hammer and anvil. Cut another piece of the rod to make the arch for the spreader at the thigh. Make it long

enough to bend around both bars of the splint, and make a half circle, spreading the bars 10 or 11 inches as needed; now bend over a chair or anvil both bars at the knee distance, the amount of flexion desired, and the splint is ready for application, except the hooks for the suspending cords. These may be easily fashioned with

Fig. 71.—Pad well the heel, tendo Achilles, and malleoli before applying Buck's extension.

pliers from light wire, or the cords may be tied directly to the splint bar and secured from slipping by a piece of adhesive tape. A good blacksmith with heat may fashion it somewhat better by welding on the spreader and the hooks for the suspending cords. Lighter iron may be used for a child, or heavier may be used for first aid splints. Suppose we are to apply a Hodgen splint for

a fractured femur. We have our patient in bed, after having transported him to it with perhaps a padded board side splint. We have made our diagnosis on the signs and symptoms, with the least possible manipulation. We have not set the fracture but have tried to prevent further injury. The next systematic procedure would be to apply Buck's extension. First, shave the hair from the leg and thigh. Then put some cotton padding over the bony prominences, the malleoli (Fig. 71). After that cut a block of wood for a spreader slightly wider than the malleoli, and put a hole through it for a cord to pass through with a knotted end. This cord is for the application of the extension by weight over pulley first, and when the Hodgen splint is applied, to be tied to the foot end of the splint, making extension within the splint. Now apply, with assistance, the adhesive plaster and bandage the leg and thigh (Figs. 72 and 73). The adhesive plaster may go to the point of fracture in the femur or even higher, and always should extend above the knee joint. Compound fractures and lacerated wounds of the soft parts would necessarily modify the application. After the application of Buck's extension, we may put on weight and support the limb by sand bags or pillows, and make our splint most leisurely. Next day or later it may be applied if the patient is shocked, for further worry of the patient, in such cases, is not advisable. Or, we may proceed at once by getting the measurement of the limb as described above, and have a blacksmith make the splint while cords and pulleys for suspending apparatus are secured. The patient has now been placed in the room and on the bed most suitable for his comfort, with light coming from the head of his bed so he may read best. Also, there should be enough room so that the bed

Fig. 72.—Applying the adhesive plaster for Buck's extension. The block or spreader a little wider than the malleoli, the leg shaved. The adhesive may go to the fracture site or even above. Apply always to above the knee joint, when possible.

Fig. 73.—A light roller bandage over the adhesive or diagonally applied additional adhesive slips may be used.

may be moved to increase or decrease the extension pull after the pulley is fixed in the ceiling. This pull is measured entirely by the distance the patient may be from the vertical line from the suspending point. If the suspending pulley is fixed to a support from the bed, of course the position of the bed in the room is of no consequence. After fixing the pulley, and fixing the suspending cords to the splint, the splint is let down over the limb, and the Buck's extension tied securely to the crossbar at the

Fig. 74.—The pulley, suspension cords, and splint are arranged and let down on the limb. The extension cord is tied to the end of the splint. Three or four suspending slings are put under the leg and thigh. The limb is then elevated and extended. Adjustments are quickly and easily made by the tent blocks.

foot. One or two bandage strips are put under the leg and the thigh; the suspending cord is shortened; and the limb suspended and extended (Fig. 74). Now, to complete the work, the bandage muslin strips are cut and pinned with ordinary pins, first fixing on the inside and then to the outer bar of the splint. Each bandage is overlapped one half distance, and the pin is put through the overlapping part. The upper edge is left free until the next strip is applied, and both are pinned together and drawn taut, so that, finally, the entire limb is sup-

ported by a smooth, even-fitting sling which accurately follows all the curves and nowhere presses too much. When the upper part of the thigh is reached, the strips on the inner splint bar must be overlapped several times, and the outer longer bar receives them regularly to the end opposite the trochanter, making the bandages fit accurately on the thigh up to the gluteal fold. This arrangement is important with fractures of the upper thigh, and gives more support than when the splint bars

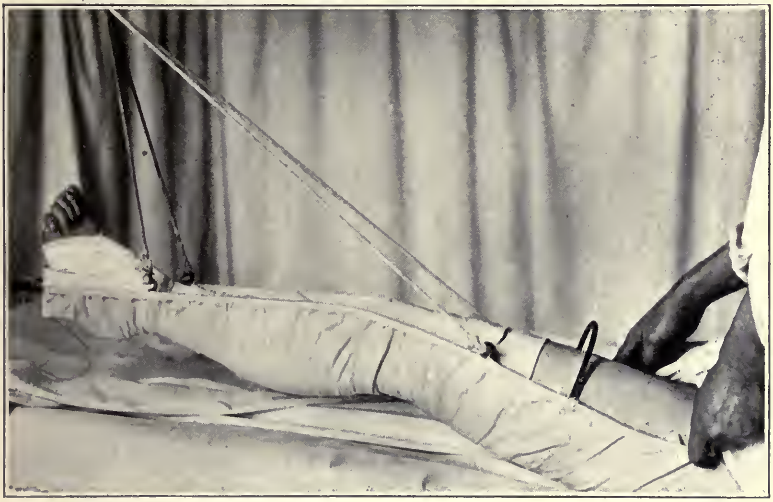

Fig. 75.—The suspending slings are applied from the heel to the hip. The internal splint bar reaches to the os pubis. The external reaches to the trochanter. The top of the limb should be about level with the splint. The thigh portion here is slung hardly low enough.

are of equal length. Fig. 75 indicates the relative length of the outer or inner splint bar applied. Of course, other means of making the supporting sling may be used. The old Scultetus or tailed bandage may be used and adapted perfectly to the curves, if pinned on to the bars properly. It is not possible to make the most comfortable and smoothest fitting sling if a single piece of canvas or

domestic is used. Also, in case of compound fractures and the care of wounds, the Scultetus bandage or the domestic strips are removable at the site of the wound, without disturbing the rest of the sling. The patient is now suspended in this splint, and no attempt has been

Fig. 76.—Shows the splint applied with a spring scale measuring a weight of 25 pounds. Vertical suspension and no inclination of cord to make extension.

made, nor will any attempt be made, to *set* the fracture. With a spring scale we can easily measure the desired amount of force to be used for extension (Figs. 76 and 77), not forgetting, of course, to elevate the foot of the bed sufficiently to be sure of counterextension. The amount of extension pull needed must be a matter of

judgment and experience. A strong laborer with heavy musculature will, of course, demand a much stronger pull. Inspection and measurement, which is so easy in this splint, tells us when we have full extension, or even more, inspection notes the contour and symmetry and will also tell us if anatomic form is being restored, and, therefore, if we are securing the best possible chance for functional recovery. When we add to this the ease of in-

Fig. 77.—Shows the splint applied with the inclination for extension. The scale shows a pull of 50 pounds making a suspending pull of 25 pounds and an extending pull of 25 pounds.

spection of the bone itself by x-ray we are accomplishing still more, and if needed can readily change our applied forces for the better. To maintain the even constant extension so essential, the entire weight of suspension and extension may be put on the end of the cord over the pulley. It is then impossible for the patient to get away from it, whatever his position may be in bed.

(See Figs. 107, 108, 109, 110, 111 and 112.) If the cord is fixed, the extending force may be lessened by the patient's sliding down in bed, but with a long cord it is not materially changed. This tendency is easily overcome, however, by having sufficient elevation of the foot of the bed, and sufficiently high suspension of the limb. This height and pull can be quickly and easily regulated by any kind of an attendant, if the ordinary double cord or the pulley with a tent block is used. This plan is easier than trying to tie the other end of the cord to the foot of the bed and letting it slip. The only particular care must be that the patient's leg should not rest on the bed. How much weight? As mentioned above, that must be a matter of good judgment and observation. It does not take a great amount in our experience, especially after the first few days of muscular spasm, and it is not necessary to overcome that at once; twenty-five pounds is probably the maximum ever needed; and the weight can gradually be reduced, as the case progresses, until finally little more than suspension is needed. It must be remembered that it is the unintermittent, even pull that soon overcomes all muscle spasm, and makes the requisite extension. From six to fifteen extension pounds, as the case may be, is enough. After the first days have passed, then, we have a general relaxation not only of the spastic limb but of the entire patient, and he settles down to the most perfect comfort possible for such a situation. Compare the complacent model, which is not exaggerated, in Fig. 78 with the model in Fig. 48, and note the possible mobility of the patient in Fig. 79.

And do we maintain that the Hodgen splint is applicable to practically all fractures of the neck and the

lower third as well as the shaft? It is truly so; for by only slight modifications every demand can be met for the treatment afforded by any other apparatus. For the neck of the femur it is just as applicable as for the shaft; for we get the requisite support and extension needed; and, as most of such fractures are in the aged, we secure

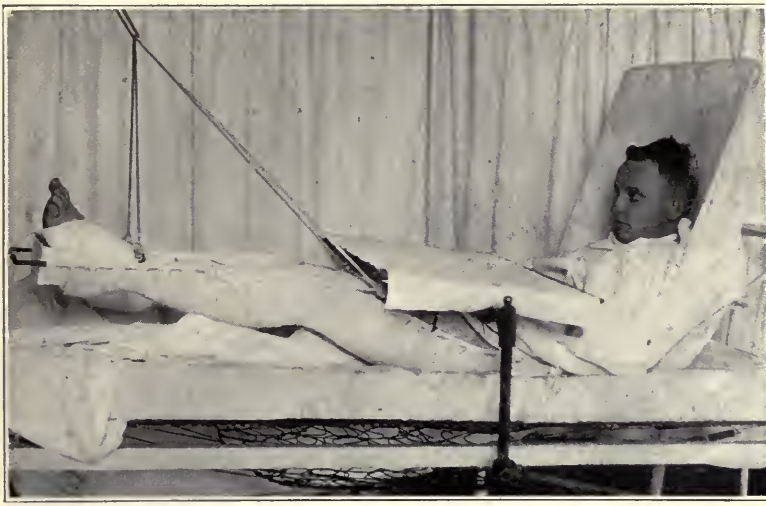

Fig. 78.—Illustrates the proper application of the splint, patient semi-reclining.

all the other advantages of mobility, suspension, and comfort.

Any amount of abduction may be obtained which is necessary to correct coxa vara. That coxa vara trammatica described by Whitman, and corrected by his plaster spica at 45 degrees abduction (Figs. 28, 29, 30, and 31), is also corrected much more comfortably by the Hodgen splint, suspended at such an angle pulled out from the median line (Fig. 117). Varying degrees of that abduction may be demanded for subtrochanteric and fractures of the upper third of the bone. For a

fracture in the upper third (Fig. 23), with the upper fragment somewhat flexed and abducted and the lower one drawn inward and upward, the best position of the splint would be good flexion at the hip secured by high

Fig. 79.—Shows the amount of possible mobility for the patient.

suspension and abduction of 20 or 30 degrees. In fractures in the upper part of the middle third, the upper fragment is displaced forward and outward, so that the natural pull would still be high abduction. But if the fracture is near the junction of the lower and middle third, the great abductor muscles would pull the upper fragment forward and inward, and the lower fragment

would be displaced outward and backward. A straight line or slightly abducted suspension will be found best for fractures at this point. For a fracture in the lower third, or the supracondylar, which is usually oblique from above downward and forward, with displacement

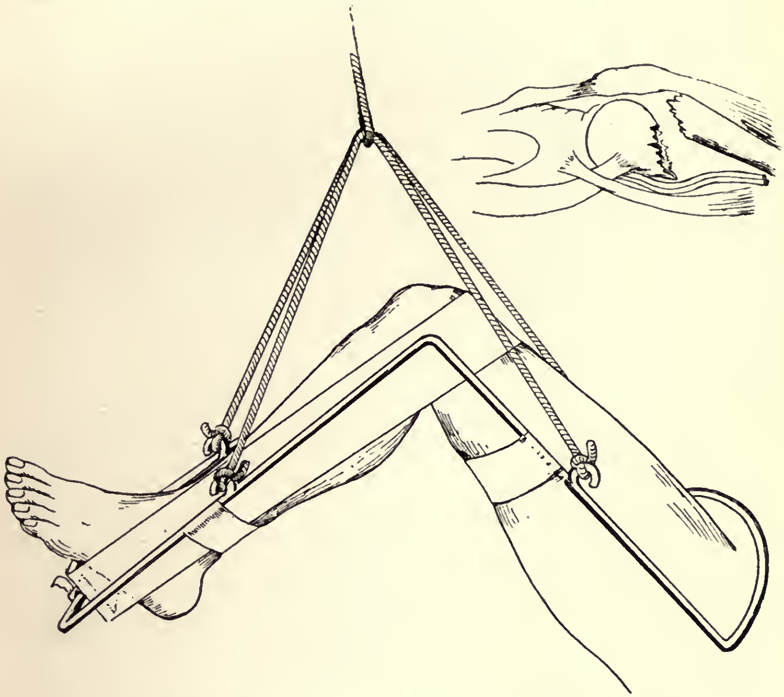

Fig. 80.—Illustrates the proper application of a Hodgen splint for a supracondylar fracture of the femur. The splint is bent to an angle of 45 degrees. The adhesive straps of the Buck extension overlap above the knee. This position relaxes the muscles of the calf, pulls down the extension muscles of the thigh, and lets the ends appose. See insert above.

of the upper fragment forward, and the lower sometimes pulled down acutely by the gastrocnemii muscles (Fig. 24), we will need the splint applied with flexion at the knee of a right angle completely to relax the gastrocnemii muscles, with high suspension and extension with the plaster applied over the knee, as in Fig. 80.

These examples, in a general way, will indicate the applicability of the splint. It will be seen that extension can be made in a great variety of directions and at varying degrees of flexion or extension of the joints. Accurate diagnosis will go far to indicate the proper application of the forces through the splint, and more than all x-ray inspection at frequent intervals will show the effectiveness of the extension and demonstrate the need for any modification of the extension force and the direction of application.

CHAPTER VIII

THE HODGEN EXTENSION SUSPENSION SPLINT IN WAR

It was the exigencies of the great Civil War which developed the Hodgen wire cradle extension suspension splint. Hamilton says, "I regret that in earlier editions, when referring to this apparatus, I have spoken of it as having been employed by Dr. Hodgen in gunshot fractures alone, while in fact it is employed by him in all, or nearly all, fractures of the femur. The error came probably from the circumstance that I had myself seen it used only for gunshot fractures." This early impression may have had much to do with the lack of popularity and general use of the Hodgen splint in civil practice, where its usefulness has been as well demonstrated as its war uses. Still, it must be evident to all that it has peculiar usefulness in the treatment of compound fractures and wounds of the soft parts, and is, therefore, particularly fitted for war service. A review of recent war practice will show that the wire cradle type of splint, both for first aid and transport and for permanent treatment, is the most popular. Such a review will demonstrate also that the most successful appliances are those which incorporate the principles and most nearly approximate the Hodgen splint.

In war service, a splint that will serve for transport may be quite unsuited for a permanent appliance. A Liston splint (Fig. 25) serves an excellent purpose as a fixation apparatus, preventing further injury, and per-

haps making moderate and sufficient extension for transport; while it is very unsuitable for permanent use, especially when compound fractures are to be treated.

The unmodified Hodgen, though the most effective as a permanent appliance, would prove of less value than a Thomas knee splint (Figs. 50 and 51) in transport, because, with the fixation, no provision is made for extension and counterextension on the perineum.

The Blake splint is modified from a Hodgen apparently; and by putting the spreading arch below, it can be made to impinge on the tuber ischii and extension and counterextension be sufficiently secured for fixation and transport (Fig. 69).

The Cabot posterior wire splint is also suitable for first aid (Figs. 35 and 36).

The Thomas double frame, adapted by Robert Jones (Figs. 39 and 40) to serve as a stretcher and first-aid splint, is no doubt very ingenious and useful. It fixes the entire patient so securely that it seems an ideal apparatus. The size of it must militate somewhat against its use. The smaller wire frames occupying so little space in ambulance can always be at hand, while the larger apparatus may not. Nothing could be easier than to have a stack of Hodgen, Blake or Thomas splints in ambulances for first-aid use; and their simplicity would insure their proper application.

Groves' double-inclined wire sling (Fig. 34) is made for transport and is said to be used with great satisfaction. He had then made in "*stacks*" for easy transportation to the front, as a small light apparatus was an important consideration. The more compact and the lighter the appliance that must be got to the injured soldier, the more chance it has of serving him.

The Hodgen splint, although having no ring around the thigh for counterextension, may very easily be modified and made into an excellent transport splint. The illustration herewith (Fig. 81) represents the construction, and to meet all requirements the dimensions should be enough to accommodate any thigh and leg with the necessary first-aid dressing. The inner bar should be 40 inches; the foot 6 inches, the outer bar 46 inches, and the spread at the thigh 12 inches. The eye for the strap

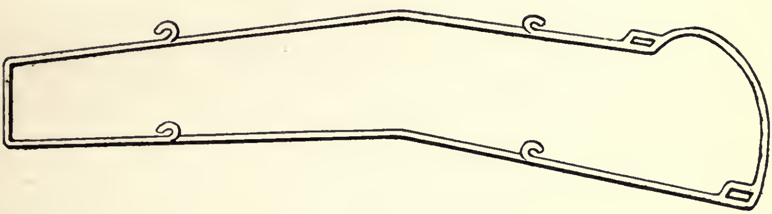

Fig. 81.—A modification of the Hodgen splint suitable for transport service. Inner arm is 40 inches long; outer arm is 46 inches long; lower end is 6 inches wide; upper end is 12 inches wide; openings at the upper end for a strap or padded cord.

as indicated, and any ordinary leather strap may be used, as for instance a man's waist belt. The arch should be padded as well as the strap. The splint is simply placed on top of the limb, without moving the patient. It is not necessary to lift the limb and insert the leg through the ring as is the case with the Thomas splint. The strap is brought under the thigh and buckled snugly. Then the adhesive strap may be applied for extension, or a clove-hitch around the foot may be tied to the cross-bar of the splint, when sufficient extension is made. A few supporting slings are then applied under the leg and thigh, and the patient is ready for the ambulance with the least possible manipulation (Figs. 82 and 83).

Fig. 84 will indicate the use this modification may serve in a compound gunshot fracture of the thigh. It indi-

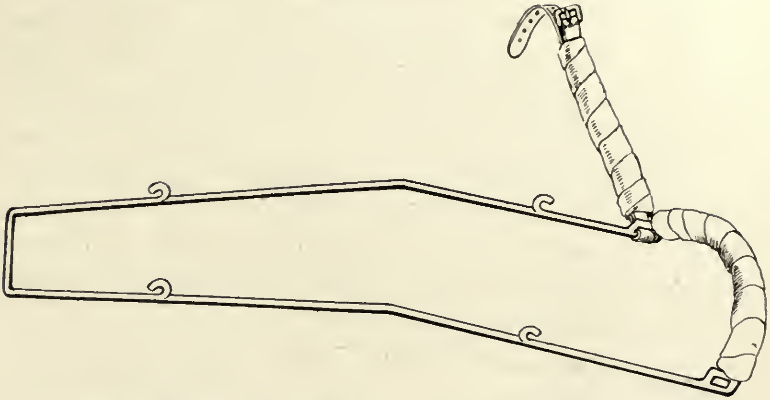

Fig. 82.—Shows the transport splint open ready for application.

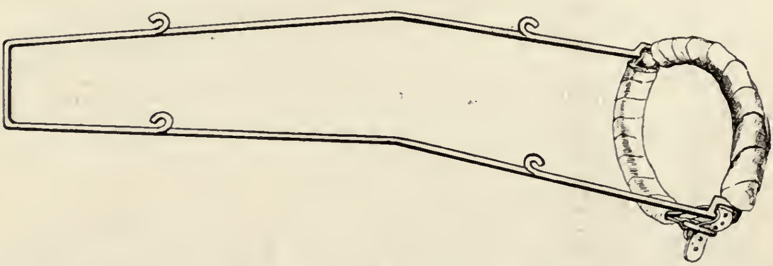

Fig. 83.—Indicates the manner of strapping transport splint to the thigh.

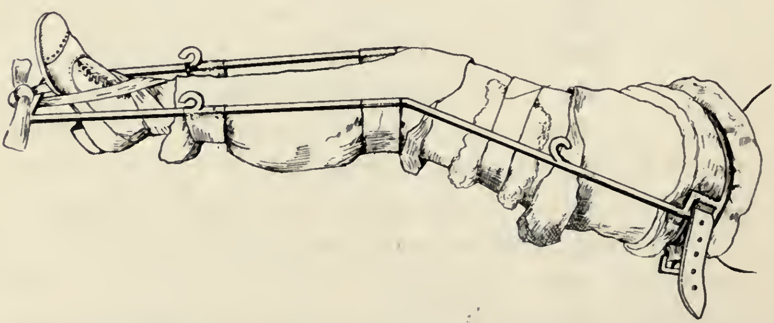

Fig. 84.—Shows how transport splint may be applied at the front. A first-aid dressing is applied, a blanket or coat is put around the thigh and pelvis for padding and the strap is buckled over this. The foot is slung to the cross-bar at the foot with sufficient extension. The limb may be suspended to the roof of the ambulance.

cates that the clothing is torn away, a first-aid dressing applied, a blanket is wrapped around the thigh for padding, and the splint buckled snugly. Extension is made and the foot tied to the bottom of the splint. Such a light wire splint might be carried in all ambulances, and used for first-aid service in any case which needs immobility for the lower extremity. When the patient reaches his base hospital no other splint is needed. It is

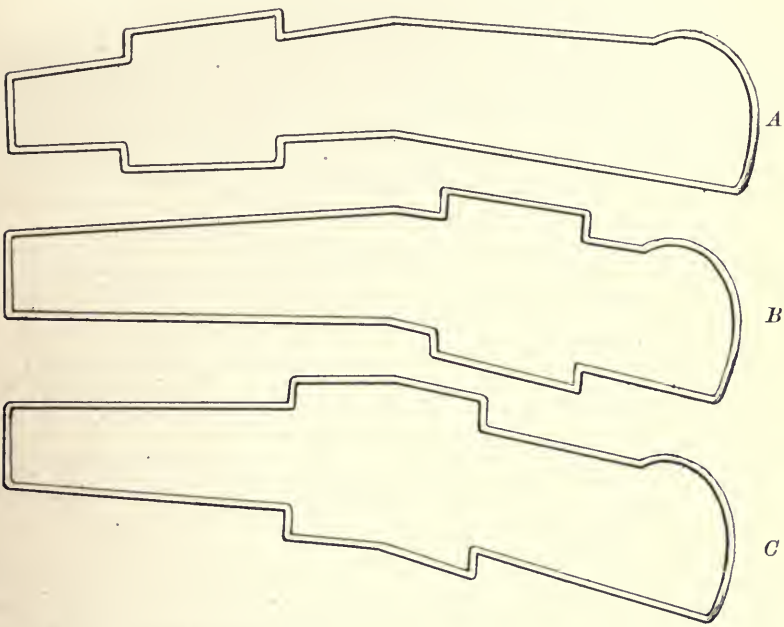

Fig. 85.—Shows model of modified Hodgen splints spread at the leg (*A*), thigh (*B*), or knee (*C*) to make more room for dressing compound fractures.

only necessary to apply the suspension and extension desired in the same splint. The strap is removed, and all counterperineal extension is taken away. Many other modifications of the Hodgen splint might be made and still preserve all the essential principles of its construction. For instance, any part of the wire frame may be

angled out and widened to give more space for the dressing of wounds. Fig. 85 will show it is possible to get the additional room needed at the leg, knee, or thigh.

Figs. 86 and 87 will show how the splint may be constructed so that the adhesive straps for the Buck's extension will need no spreader block, but they may be attached to the posts at the corner of the lower end of the splint.

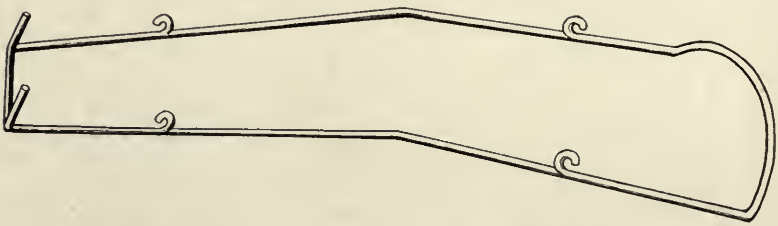

Fig. 86.—Shows a modification. The upright posts serve as points of attachment for the extension straps. No spreading block is needed.

Fig. 87.—Serves the same purpose as Fig. 86.

Figs. 88 and 89 will also show how extension may be made at the knee by attaching the adhesive plaster to the posts or the splint arch, as the case may be. This modification may be useful when the leg and foot are injured, as well as when the injury is in the upper thigh. For extension at the knee, the splint may be made as in Fig. 90, where adhesive plaster and spreader block may be applied, and the extending cord be tied to the upright

offset of the splint. Or, in case extension should be desired by the use of Steinmann's pin or Groves' clamp, it may be secured as shown in Fig. 91. Such are some of the modifications which may be used; but in none will we depart a particle from the essential principles exemplified by the Hodgen splint.

Suspension, intraextension, immobility of the fracture,

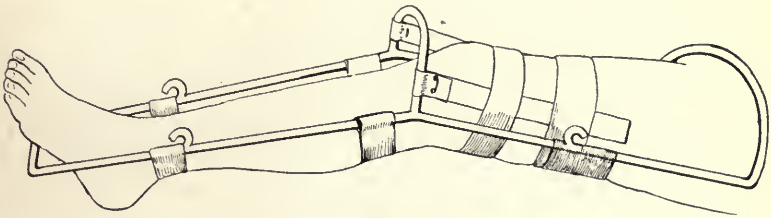

Fig. 88.

Fig. 88.—Illustrates how extension by adhesive straps may be made at the knee.

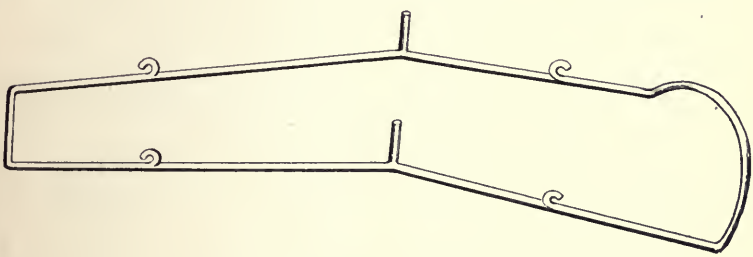

Fig. 89.

Fig. 89.—Shows the same as Fig. 88.

mobility of the thigh and the patient are all secured in the same way.

In another place we have mentioned the great value of this wire cradle type of splint in treating compound fractures, and it is this value no doubt that makes the Hodgen splint particularly desirable as a war splint. In no other injuries should the patient himself receive more

attention, and any and every factor conducive to his comfort and general welfare should be used. With these horribly mutilated and infected wounds, the bone injury is a secondary consideration. First, the infection must be controlled by all means possible, free drainage removal of septic and dead tissue and irrigation. To have

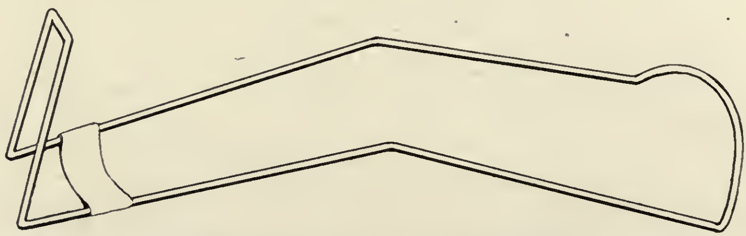

Fig. 90.—Shows a modification with greater offset at the front for either adhesive or clamp extension from the knee. This splint should be of somewhat heavier iron than is necessary without the offset.

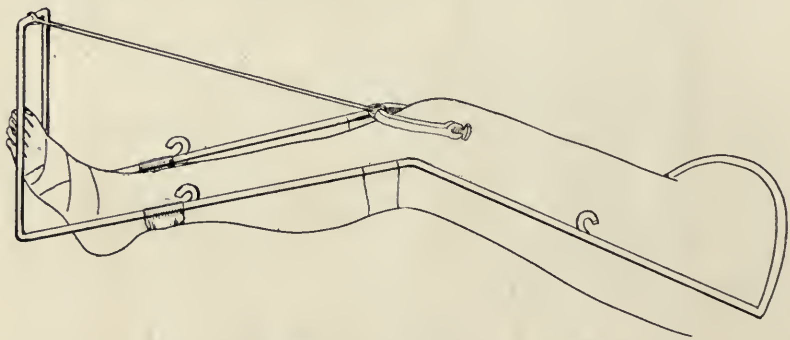

Fig. 91.—Illustrates how the Hodgen splint may be used with Steinman's pin or Groves' clamp and still preserve full mobility of the limb. This intraextension permits the full mobility of the limb and patient.

the limb suspended above the bed is the most favorable position possible, because the drainage and dressing and irrigation can all be done with the greatest facility. This, then, is where the principle of suspension in the Hodgen splint is of peculiar value. The dressings and bandages are applied easily by simply removing some of the sus-

pending sling at the site of the wound. Irrigation may be used for the leg or the thigh as indicated in Figs. 92

Fig. 92.—Illustrating the use of irrigation in the leg. The fountain attached to the suspension cord.

and 93. To appreciate the ease with which this irrigation procedure is done in suspension, one must have

tried to do it with the leg flat in bed. No other splint than the open wire splint permits this procedure. Irri-

Fig. 93.—Illustrates the use of Dakin's solution in the thigh.

gation may not be done with any satisfaction when using boards, plaster, or simply extension when the limb is on the bed.

Fig. 94.—Showing the use of the fluoroscope and advantage of the Wallace bed. Looking down through the leg.

Fig. 95.—Illustrates use of fluoroscope looking transversely, showing ease of use because of suspension.

Suspension is adapted to another procedure which is of great value in the treatment of fracture of the femur;

Fig. 96.—Looking down through the hip. The patient's hip is projecting over the edge of the bed. The free mobility of the patient permits the easy use of x-ray examination.

namely, the facility with which the limb may be examined by the x-ray. In no other way can we get more accurate information concerning the apposition or rela-

tionship of the bones; and by routine examination we will be able to modify our forces as needed. It may be we need more extension, and we can have it; or perhaps more abduction or more flexion at the thigh or the knee. These forces may be applied in the degree needed, and such definite information as to the needs will be obtained by the routine examination. With a portable x-ray machine the patient may be examined from every direction

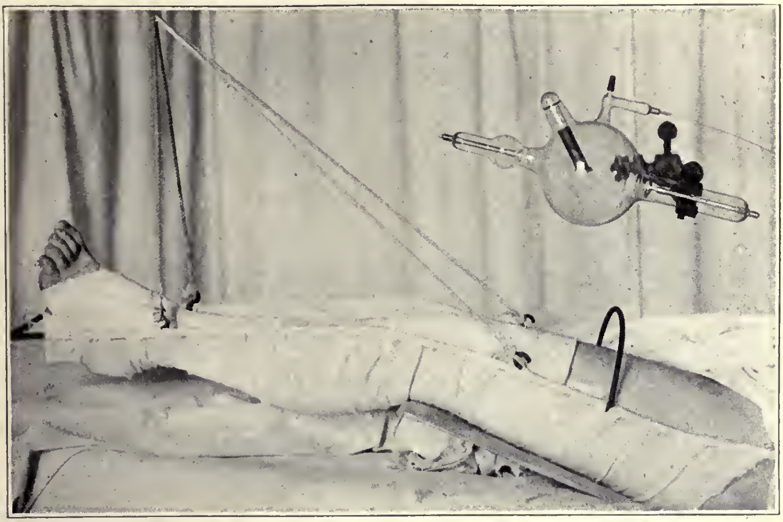

Fig. 97.—Shows x-ray tube and plate. Illustrates the ease with which x-ray examinations are made.

daily with fluoroscope and any modification of forces applied at once as needed. The accompanying illustration will show how easily this great help in the treating of fractures may be used with the Hodgen splint.

The leg may be examined by putting the tube below and looking downward as in Fig. 94, or transversely as in Fig. 95. By putting the patient over the edge of the bed we may look downward through his hip joint as

shown in Fig. 96. A plate may be used anywhere as shown in Fig. 97. The x-ray also advises us when it is impossible to obtain reduction that is proper and sufficient, and indicates when operation is necessary. With the systematic examination and the proper application of the Hodgen splint the operative work will not be 38 per cent of cases (Estes: *Annals of Surgery,* July, 1916), as indicated by good authority, but very much fewer.

CHAPTER IX

THE HODGEN EXTENSION SUSPENSION SPLINT FOR THE ARM AND FOREARM

In a general way the anatomic conditions to be met in the upper extremity do not differ from those of the lower extremity. The functioning is different, it is true; for we have ceased to ambulate on all fours.

The principles of treating fractures of these long bones do not differ essentially from the others, but they are modified, as a rule, by a patient's ability to walk about. The more severe and mutilating compound fracture in the upper extremity might well be treated according to the general principles laid down for treatment of the thigh and leg. We have to consider a very similar anatomy. In the first place, we have a ball-and-socket shoulder joint, with even wider range of mobility than the hip joint, and the whole is further mobilized by the free movements of the scapula on the chest. This makes it almost impossible to immobilize the shoulder joint itself, if it should be desired.

The brachial fascia in its enveloping of muscles and attachment to humerus is not unlike the fascia lata, and will act, when extended, in a very similar way in restoring anatomic contour and replacement of fractured bone. The same tendencies to shortening and displacement of bones are to be met, except they are modified somewhat because of the lighter musculature. With the same anatomic conditions to be met, and only modified functioning, the essential principles of treatment applicable

to the lower extremity are applicable to the upper extremity. To treat a fracture of the humerus successfully, the site of fracture must be immobilized. This may be done by coaptation splint but still better by splints with extension. The extension will have the same effect in reducing the fracture of the humerus as it does in reducing the fracture of the femur, as has been explained. Extension is the second great principle of treatment, and the most important, for by extension we not only help to reduce the fracture and splint it, but prevent overlapping, shortening, and deformity and consequent loss of function. Because moderate shortening is not so noticeable, and does not so much interfere with the functioning of an arm as of a thigh, the extension principle of treatment of fractured arms has not been accentuated. For the restoration of anatomic form and function, however, it is just as applicable and just as important as for the lower extremity. Only the principle of suspension is of less importance for the upper extremity, because the arm need not be used for locomotion, and there is more general good for the patient when he is ambulant than the comfort from suspension would give if he were confined to bed. Until the patient's condition permits his getting out, however, this principle of suspension should be used in the apparatus wherever possible, as it will add to comfort and well-being.

Suspension is particularly applicable to cases of compound fractures and infected wounds which need irrigation and dressing. In the treatment of war wounds, all the advantages secured in treating fractured femurs are likewise secured when treating the humerus. There is the same care in dressing and the great comfort and mobility of the patient in bed. There is added, too, the

application of irrigation and the examination by x-ray. The open wire cradle type of splint will also give opportunity for care of the soft tissues and skin, and will leave the arm always open for measurement and inspection. This must always be a great advantage to us in obtaining anatomic form, which, as we have seen, is almost synonymous with good function.

The more modern, especially the war, surgeons have

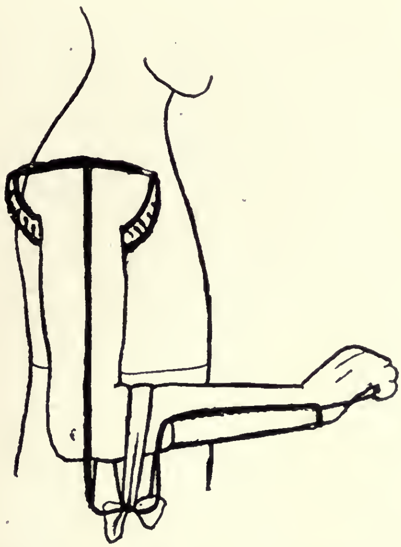

Fig. 98.—Modified Thomas' humerus-extension splint applied. (Jones—*Notes on Military Orthopedics.*)

seemed to recognize the great value of the extension principle for the upper extremity, as they have for the lower extremity. Many ingenious devices are used to secure extension. Of course extension implies counter-extension, and this has been secured by the counter-weight of the body, by an axillary counterpressure, by the double-inclined-plane principle, and the weight of the arm. The class of humerus extension splints in

which ambulation is permitted and counterextension made by pressure in the axilla, is represented by an excellent one which Colonel Sir Robert Jones calls a modified Thomas humerus-extension splint (Fig. 98). For inspection, care of wounds, and general comfort, it would be hard to excel. The extension is ingeniously applied, and in ambulation the weight of the limb is also added as an extension force. No objection could be made to it,

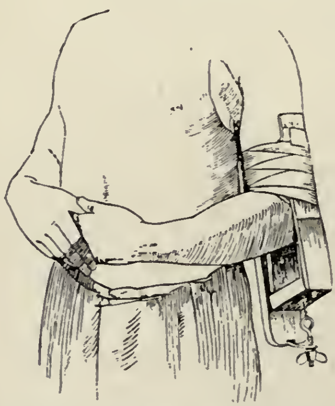

Fig. 99.—The Y-shaped crutch splint for extension of fractures of the humerus. The screw adjustment depicted may be dispensed with, and the spring tightened by pulling on and knotting the cord attached to the wooden stirrup. (Groves—*Modern Methods of Treating Fractures.*)

except that there is axillary pressure. A splint of similar use and ingenuity is Borchgrevink's, used in the Balkan War (Fig. 99). This likewise is valuable as an ambulatory splint. The extension device is very similar. The apparatus used in the great war by the Harvard unit (Fig. 100) is also of much value, and applicable to treating compound fractures while the patient is up and out.

A principle of extension over a double-inclined plane, one which also allows the patient to be out, is shown in Fig. 101. This splint may be of wire, boards, or plaster,

as desired; much of the extension is due to the weight of the arm and splint. Of course, many cases of shocking injury and infection are not at first, at least, ambulant

Fig. 100.—An ambulant splint used by the Harvard unit in treating some cases of compound fracture of the humerus in extension and abduction. (Fauntleroy.*)

cases, and must be in bed with the best device possible, not only for the fracture treatment but for wounds and sepsis. Methods of extension and suspension essential

* Report on Medico Military Aspects of the European War, Bureau of Medicine and Surgery, Navy Department.

in caring for the wound as well must be devised. All manner of schemes may be used to suit the case. The reader will note below a picture, representing the treatment of a compound fracture of a humerus, from Dr. Blake's service (Fig. 102). Suspension and extension

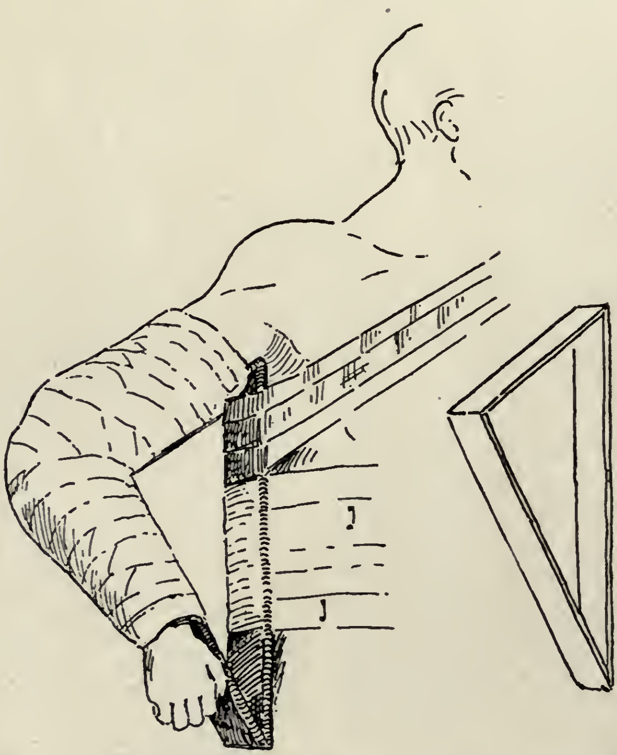

Fig. 101.—The humerus triangle. This splint is one of the most useful splints for the treatment of fractures of the arm and forearm. (Hull—*Surgery in War.*)

are here being applied. In Fig. 103 will be seen the method of the Harvard unit for treating a compound fracture by extension and abduction. Very excellent results are reported from these methods. In fact, these methods have been the ultimate achievement in this work

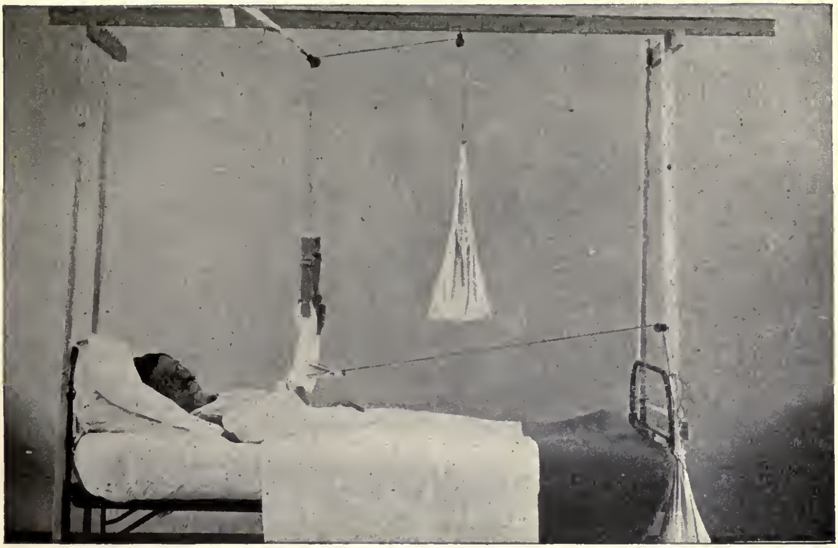

Fig. 102.—Compound fracture of middle third of humerus treated by overhead extension. This patient had so far recovered when this photograph was taken as to be able to get considerable voluntary motion out of the elbow joint. (Fauntleroy.*)

Fig. 103.—A method of treating a compound fracture of the humerus, by extension and abduction, as used in some cases by the Harvard unit. (Fauntleroy.*)

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* Report on Medico Military Aspects of the European War, Bureau of Medicine and Surgery, Navy Department.

up to this time. They give extension, suspension, open treatment, and a certain amount of mobility in bed. A type of splint not permitting ambulation is shown in Fig. 104, which is suspension, extension, and counter-extension by weight of the body. The so-called Thomas knee splint is also adapted to the humerus as well as to the femur, and is shown in Fig. 105. It may be sus-

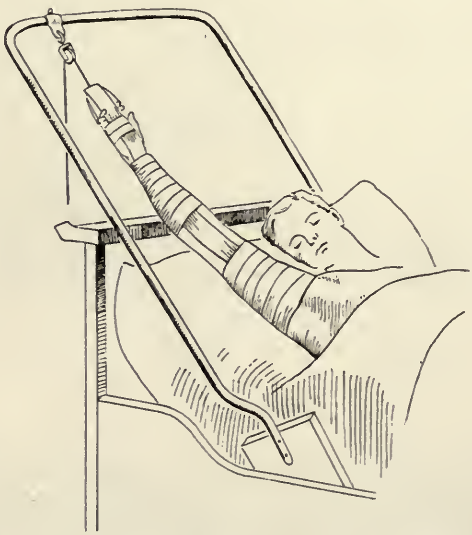

Fig. 104.—Method of plaster extension of arm fracture. (Groves—*Modern Methods of Treating Fractures.* After Bardenheur.)

pended as shown, and is useful in compound fractures. The ring, when used as counterextension, must be uncomfortable and harmful to the axilla, if much force is used. We see in these different splints again the more or less successful efforts to incorporate the several most essential principles of the treatment of fractures of long bones. First, the immobilizing of the fractured bone itself; second, note the application of the principle of extension; third, see to the securing of mobility of the

patient either for ambulation or for mobility in bed; fourth, observe the application of devices permitting the facilities for caring for infection and open wounds.

In our consideration of the treatment of fractures of the femur, we have in the previous chapters exemplified the Hodgen extension suspension wire cradle splint, and demonstrated its peculiar adaptability to the treatment of such fractures, as it meets practically every demand

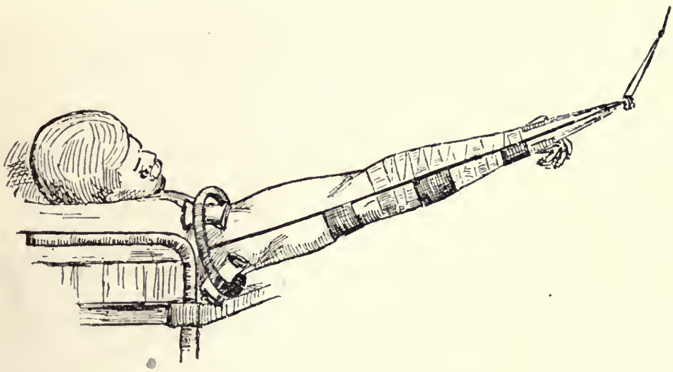

Fig. 105.—Thomas' splint for fracture of the humerus. The extension strapping is applied to the lateral borders of the forearm to allow movement of the hand. The supporting cord is attached to a ring in the wall or a special upright. The tension of this cord determines the extension and exercises an effect similar to the suspending cords of the Hodgen splint. Pressure on the axilla will be obviated by increasing the pull of the suspension cord. Here, as in the case of the femur, the limb at the site of fracture may be supported by placing a plate of perforated zinc below the arm. The zinc is retained in position by bending the edges of the plate over the lateral bars of the splint. The disadvantage of this splint is that the patient must remain in bed. (Hull—*Surgery in War.*)

for both simple and compound fracture treatment, in both civil and war practice.

We see, also, that the principles of treatment of the upper extremity are practically the same as for the lower extremity, and modern surgeons have abundantly recognized these facts by the appliances they are using. Then, if the Hodgen splint, as we believe, is the very best splint that may be used for the lower extremity, we

must also conclude that it is not inferior to any that have been used for the upper extremity.

Various modifications may, of course, be made to suit

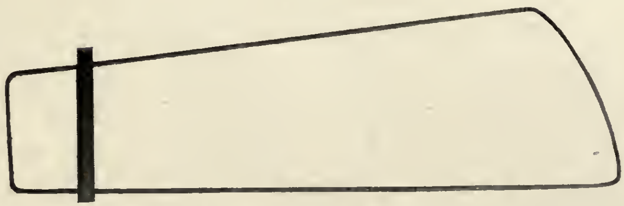

Fig. 106.—Wire frame straight Hodgen splint for the left arm. The sliding block of wood is padded and used as a grip or hand rest. The suspending cords are fixed at the proper points on the splint by a piece of adhesive tape.

Fig. 107.—Illustrates the application of the Hodgen splint to the arm. Extension and suspension are regulated as in the lower extremity.

Fig. 108.—Shows the splint applied and the patient sitting in bed. The extension is continuous and made by a definite amount of weight. Here it is six pounds.

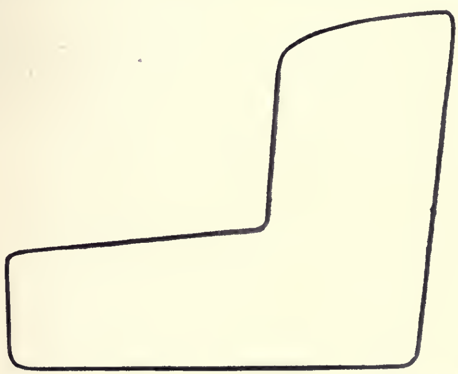

Fig. 109.—The arm splint bent at the elbow. Extension must be made at the elbow partly. The forearm is padded just below the elbow and adhesive fixes it to the outer arm of the splint.

the case as to the location of the fracture and the treatment of wounds when necessary. Any degree of flexion of the elbow may also be obtained, and extension may be made either at the elbow or the hand, with suitable application of adhesive plaster. Provision is, therefore, made for physiologic flexion, and also for possible elbow joint ankylosis, which will leave an arm in the most useful

Fig. 110.—Shows the splint applied. The bed standard is used (Fig. 116) and the arm is extended, suspended, and abducted. A continuous even pull of six pounds is made.

position (Fig. 106). The photographs show a model wire straight Hodgen splint for the left arm and forearm. A stick of wood, notched to slide on the wire, is used as a handrest. It may be padded if desired. The wire frame may be of lighter material than that used for the thigh. The extension plaster is applied to the

radial and ulner sides of the forearm, extending above the elbow to the fracture, or higher, if desired, in a simple fracture. The extension straps are attached to the crossbar of the end of the splint. Suspension is made in a similar way to that made when suspending the thigh, and the extension is measured entirely by the amount

Fig. 111.—Illustrates Fig. 110 in the sitting posture. Indicates comfort. Also the same advantages for use of x-ray and dressing obtained as in the lower extremity.

of inclination of the pull. The suspending sling strips are applied as in the thigh splint. Any desired amount of abduction is secured by the point from which the pull is made in relation to the bed. Figure 107 represents the application and suspension of the splint, and Fig. 108 will show the patient in a comfortable semi-reclining position, with the arm elevating as he goes up.

That there is a mild, even, continuous pull which overcomes all muscular resistance, and gives the fullest ex-

Fig. 112.—Shows the angle arm splint without abduction.

tension and immobility, and at the same time leaves the patient free to sit up and move about in bed is evident.

Figure 109 represents the splint angled at the elbow. The application differs in no way from the straight splint, except that part of the extension must be made at the elbow by adhesive plaster, to the outer splint bar. Figure 110 will show the splint applied, and the extension cords and weight producing suspension, extension, and abduction. Figure 111 demonstrates the patient sitting up with the extension and suspension and abduction unchanged. Figure 112 represents the same splint without the use of abduction, the patient reclining. These several photographic models may indicate better than any description, the uses of the Hodgen splint in the upper extremity. Any one understanding the cardinal principles of treatment, and the possibilities of the Hodgen splint, will be able with a moderate amount of mechanical ability to apply it to meet all the indications for treatment, and consequently get the best possible functional recoveries.

CHAPTER X

HELPFUL APPLIANCES

To be successful in treating fractures one must necessarily know well the anatomy and functioning of the part. He should also know pathology and the possible influence which disease, including senile changes, may have in their relation to fractures. Unless, however, he is also equipped with a *mechanical* sense he may, though skillful in diagnosis, still be a bungler in therapeusis. Some have this mechanical sense as a natural gift; others seem to lack it almost entirely. If one does not have it, it must be deliberately acquired if force and counterforce and mechanical appliances are to be at all successfully used. The lack of this fine sense among surgeons has, no doubt, been responsible for much of the crudity in fracture treatment that has been handed down to us. Empiricism, which has long been both a blessing and a curse to medicine and surgery, has nowhere more plainly shown its baneful effects than in the treatment of fractures. Now that modern scientific medicine is ascendant, now that we no longer accept without question the dictum of the fathers, it is indeed time that the treatment of fractures should become less empiric and more rational. It is time now for a more scientific fracture treatment; for in no other surgery can more harm be done from following precedent. The fear of damage suits has been one potent reason for surgeons to adhere to the *classical* and prescribed treatments of fractures; for any radical departure from these methods would ob-

viously make defense more difficult. But it is time now for a revision, and for a more rational and scientific care of fractures. The great war has developed, and will secure a still greater advance in the scientific treatment of fractures. In this great service our best men are exercising their talents and mechanical ingenuity to the utmost in order to secure the best results. But I have said that a mechanical sense is imperative. In fact, lacking this faculty, a surgeon should not treat fractures. A proper understanding of the principles of treatment is absolutely necessary for success; but however complete this understanding, it will fail to bring satisfactory results if one lacks the mechanical skill to apply apparatus in accordance with these principles. And they should be applied, not crudely, but with workmanship and skill. In the application of splints and such like appliances there are often many details and minor things which are perhaps not absolutely essential, but which contribute to the general welfare of the patient. These should not be neglected. We have tried to emphasize the fact that it is not the fracture alone which we treat; in each case we have a whole patient as an entity, an entire patient who must be cared for, not merely a part of a patient. Realization of this fact should be constant and vivid. Consideration of the patient as a whole should never be forgotten. This consideration of the patient should begin as soon as he is seen; it should be shown him in our gentle manipulation in making a diagnosis and in our care in transportation. After the patient is in his home or hospital bed, very many helpful things may be done for him. These many little things for his care and comfort total an amount which is often a great factor in recovery. No one thing

is more important than the selection of the bed. This selection must be regulated by circumstances such as the kind of fracture, age of the patient, etc. As a rule the bed should have a firm resilient mattress and springs, should be of light iron, and of the single usual hospital type, even when the patient must be treated at home. One great help in the care of both upper and lower extremities is to have a bed which can be elevated at the back, for soon the patient may use the sitting posture, and he is much easier handled with such a bed than

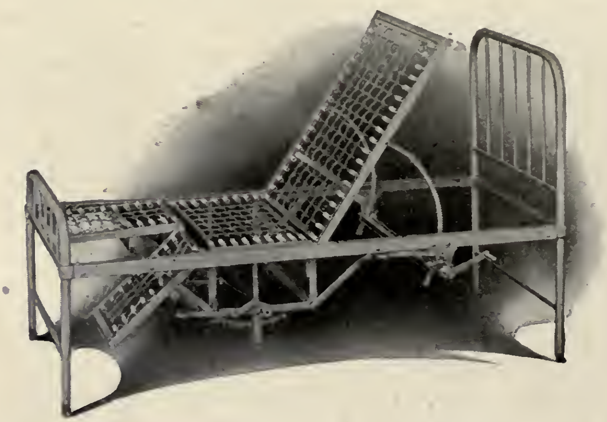

Fig. 113.—The Wallace adjustable bed. 1st. Elevation of the back—sitting posture at any elevation; 2nd. Either or both pads for the leg may be lowered; 3rd. The center pad may be lowered for use of bed pan and urinal.

when the back rest is put behind him. This type of bed is illustrated in a number of places in this text, as the reader will have noticed (Fig. 113). The foot of the bed should always be elevated to the height necessary to secure counterextension in fractures of the femur; many hospital beds have extensible legs with pins to hold them at the desired height. The necessary elevation may also be gained by using bricks or other support improvised as circumstances allow. Locating the bed advanta-

geously in the room is always important. It should be out from the walls so that attendants may get on all sides of it for nursing care. Because the patient may often read and otherwise enjoy himself, he should be placed so that the light may be used to the best advantage. The suspension to the ceiling is another consideration of importance, as are also heating, avoidance of drafts, and other irritating or unfavorable conditions.

Fig. 114.—Sitting on a Wallace bed and suspended in a Hodgen splint.

A very excellent bed is shown in Fig. 113 and in various other places in this book (Figs. 114, 115, 94, and 108). It is adjustable to almost any desired position. The mattresses are separate pads. One for the back, one for the pelvis, and another for either leg. The patient may sit erect, as in a chair, with legs up or down (Fig. 114). The middle section may be lowered, and is most valuable

on that account in the nursing care of the patient, making the use of the bed pan possible without the slightest disturbance of the patient (Fig. 115). This bed is mechanically as superior to some of the old fracture beds with a hole cut in the mattress, as a Hodgen suspension splint is superior to a Liston. No one thing, except the Hodgen splint itself, is of more value in securing the recovery of the patient than is this Wallace bed. It is

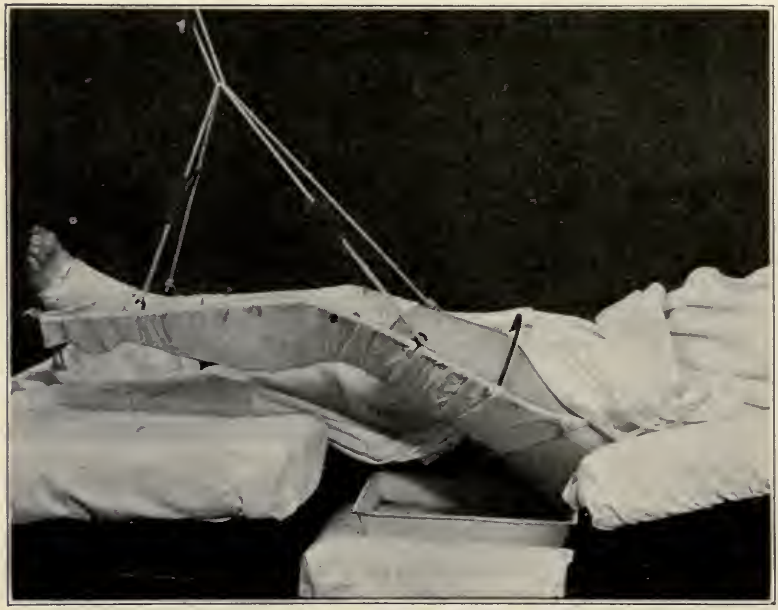

Fig. 115.—Illustrates the use of the bed pan with a Wallace bed.

especially valuable in the aged because of the early manipulation and change of position necessary for the good of such patients. Such patients may be cared for with the greatest ease; and at the same time the greatest amount of mobility is secured for them, which is most essential. Such a bed is very helpful even up to the time the patients first put their feet on the floor. The

old man first puts his feet on the floor when both legs are let down, and he is holding to the foot rail of the bed. He has less fear; and much sooner does he begin to bear weight and recover function. This bed also makes easier still the frequent x-ray examinations so helpful and essential for scientific treatment.

The suspension of the Hodgen splint may be skillfully or bunglingly done; and as this suspension cord also makes the direction and amount of extension, it must be seen that it is not a secondary thing. A pulley in the ceiling has been mentioned as a good place from which to make suspension. It gives a long radius for the suspension cord, and this makes greater mobility for the patient in the bed. With the Buck's extension within the splint, and not separately run on a pulley attached to the foot of the bed, much greater freedom is obtained, with exactly the same or even better extension. The best kind of pulley for either the ceiling or bed standard is not a wheel over which the cord may run, but a glass pulley of an awning hanger (Fig. 116).

The amount of extension, as has been explained, can thus be measured, and depends on the obliquity of the suspension cord. The entire weight may be put on the end of the cord over the pulley, as is shown in the illustration of extension for the arm, or it may be made by simply tying the cord to the foot of the bed or other fixed object (Figs. 107, 108, 110, and 114). A better way, however, is to return the cord over the pulley back to the suspending cords, and use a tent block (Fig. 116). By this means the length and height of suspension can be regulated with the greatest possible ease. These tent blocks may be used to accurately adjust the cord lengths going to the hook on the splint. They are much simpler

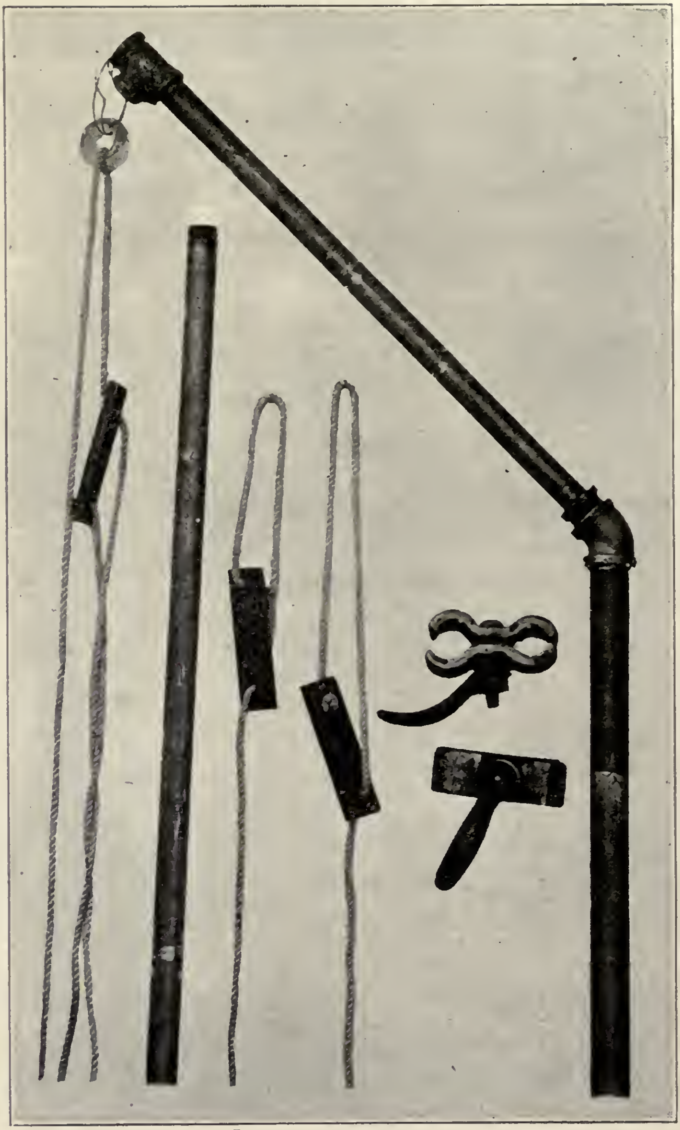

Fig. 116.—Illustrates the bed standard made of pipe. The upright is one-inch pipe, the arm is three-fourths inch pipe. The threads are cut loose so no pipe wrench is needed in changing the arm. The arm may be used any desired length. The pulley is glass, such as used by awning hangers. The two clamps are heavy and are tightened by hand. The suspending cords are best adjusted by tent blocks as shown.

to manipulate than straps and buckles, and easier to handle than tying the cord around the hook and making

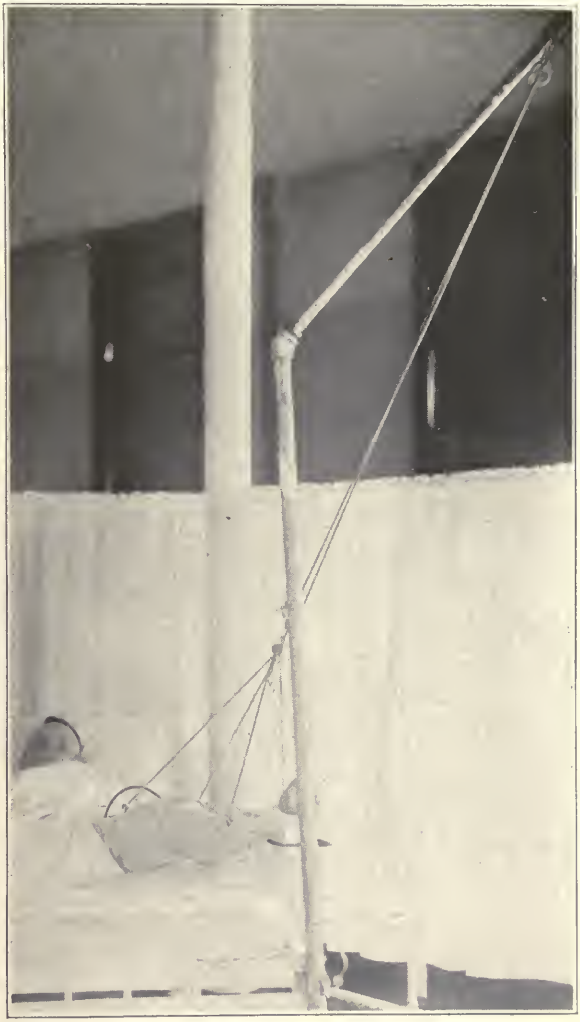

Fig. 117.—Shows the use of the bed standard for suspension, extension, and abduction. The abduction is made by the length of the inclining arm.

adjustment there. The suspension of the extension cord from a pulley in the ceiling has a disadvantage in not

allowing a change of position of the bed, since counter-extension is made by the relative position of the bed to the pulley. On this account it is often advisable to use some other device. This may be secured by erecting a wooden framework over the bed, such as the Blake frame (Fig. 70) or by the Balkan frame, making sus-

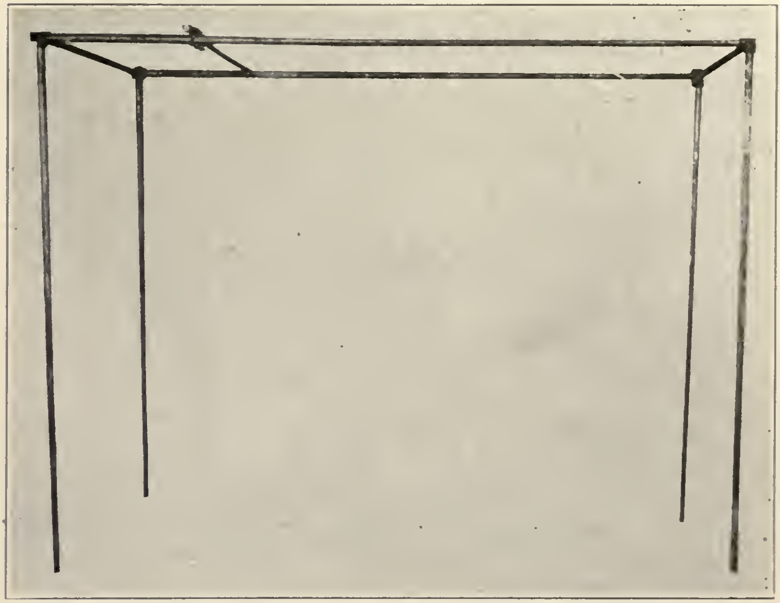

Fig. 118.—Illustrates a frame of three-fourths inch pipe which may be clamped to the bed posts and will serve as a suspending frame both for the Hodgen suspension and for slings by which the patient may move himself about in bed. The slings may be hung from the side bars. The amount of extension is graduated by hanging the pulley from the rod crossing the top of the frame. This rod may be moved toward the foot or head as more or less extension may be needed.

pension therefrom (Fig. 60). This, as will be observed, does not give the same great radius as if it were swinging from a ceiling, but makes it easier to apply the multiple pulleys pictured. Neither do these frames allow the bed to be moved about or out of doors, without disturbing the adjustments of the apparatus. To make the

patient's bed mobile, possibly even take it out of doors, we have devised a bed standard such as is seen applied in several accompanying illustrations (Figs. 111, 116, and 117). The standard is ordinary one-inch pipe, the arm being three-quarter-inch pipe if desired. This standard is clamped to the bedpost with two clamps at any desired position of the arm, which is at an angle of

Fig. 119.—Illustrates the ambulatory chair. It must be made of light strong wood. It must not be too wide but freely pass through the average 2 ft. 8 in. width of door. Length at bottom, 47 in.; width at bottom, 29 in.; length at top, 49 in.; width at top, 24 in.; height of seat, 16 in.

45 degrees. The threads are cut loose for the fittings, so that the arm may be unscrewed by hand, and a longer or shorter one put in when desired. To a pipe fitting on the end of the arm, a glass pulley is wired, and this receives the pulley rope. Now, by lengthening or shorten-

ing or swinging inwards or outwards this arm, any desired amount of extension abduction or adduction may be secured. This standard must be secured to the bedpost by rather heavy clamps (Fig. 116). The clamps are made with bolts and nuts with handles, such as a

Fig. 120.—Illustrates patient entering the chair from the bed.

farmer uses on the tail gate of his wagon. No wrench is required to loosen or tighten these nuts with handles; they are easily turned by hand.

Another device which is made of three-quarter-inch pipe is shown in Fig. 118. This frame may be clamped to the four bedposts with the clamps above described,

and the bed moved from place to place as desired, or it can be put out of doors if it is on rollers. This frame, or the Balkan or Blake frame does not make it possible to secure abduction, as does the bed standard described

Fig. 121.—Walking in the ambulatory chair.

above. Enough suspension and extension can ordinarily be secured when abduction is not needed. The amount of extension for the Hodgen splint can be regulated by tying the pulley to a cross-bar, which in turn may be fastened to any point along the top of the frame (Fig.

Fig. 122.—Sitting in the ambulatory chair.

118). Slings may be hung from the side bars of the frame (Fig. 79) and the patient thereby move himself about freely, by pulling from side to side.

These devices above mentioned are some of the adjuvants in fracture treatment; and application of them

makes for greater efficiency and superior results. A common fallacy in fracture treatment has been that good bony union was synonymous with a cure. Sometimes nothing is further from the truth. Restoration of function is finally the all-important thing. To let your pa-

Fig. 123.—Sitting in the chair and resting his plaster splint on the cross arm.

tient shift for himself, after giving him a pair of crutches, is dangerously near malpractice. Oftentimes much still remains to be done; and it should not be left to the unskilled. The longer muscles and joints are out of use, the longer it takes to get them back to normal. Much may have been done for the muscles and soft parts

in the open wire cradle type of splint, and much has been saved by the free mobility secured by the Hodgen splint. But there can be no function after seven or eight weeks of nonuse. Now, are we to give our patient, perhaps an old man, a pair of crutches, and tell him to learn to walk the best he can? He will not use the crutches. He cannot use them; he is afraid of falling. They hurt his arms, and the fact is, crutches are totally unfit for what they are supposed to do. The patient easily becomes discouraged; oftentimes he gives up, with a consequently still greater loss of power. Crutches can be satisfactorily used only by individuals with full strength and strong arms. What may be done? Certainly one, or preferably two trusted attendants to bear up the patient are good; but not always and at all times are they available. It may take quite a long time to regain strength and recover full function. Is there no more helpful apparatus that might be devised than crutches? We put a child in a baby-walker to help it learn to walk. Our fracture patients have to learn to walk again; and they have to regain gradually their muscle power, much as does a child. The child's baby-walker is a very simple and helpful apparatus, affording security from danger of disastrous falls. The principle is easily applied in a helpful apparatus which we are pleased to call an ambulatory chair (Fig. 119).

It is a light frame, as shown in the illustration, made of hickory or ash. The front end is open so that the patient may enter it from the bed, as shown in Fig. 120. Right here is produced an important psychologic effect which is lost if we hand the patient a pair of crutches. He is certain he will fall if he tries to move on crutches; but his common sense assures him he is safe in this

frame, with its four widely separate points of support. The first time he may get no further than placing his

Fig. 124.—Ambulatory chair. Safety in descending steps.

feet on the floor. He may even stand, or take a step. However, whatever little he does, his confidence has been secured; and he will not long be dependent on his own

strength until he is walking, as shown in Fig. 121. Should a patient find that he did not have strength to go more than a few steps, he knows he is safe, and all he need do is to sink down on the seat and rest (Figs. 122 and 123). In a short time patients using this ambulatory chair go everywhere, even up and down stairs without danger. There are always four points of support beside their own feet to bear them up (Fig. 124). We know of no more helpful appliance than this; and it is surprising that hospitals in general do not use some such device. Crutches, it is true, have their function; but their use comes later. As a rule they are totally unfit for fracture patients who are just beginning to walk. Crutches are one of the numerous appliances "handed down" to us; and we have used them without thought and discrimination. In the treatment of fractures, we might very well do without them.

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